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THE ROLE OF EARLY REARING ENVIRONMENTS: ENRICHMENT VS. IMPOVERISHMENT OR MASTERY VS. HELPLESSNESS.

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THE ROLE OF EARLY REARING ENVIRONMENTS: ENRICHMENT VS. IMPOVERISHMENT OR MASTERY VS. HELPLESSNESS

by

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ABSTRACT

Seventy-two male, albino rats were reared for 35 d. (d. 25-60) in one of six environments: enriched response contingent, enriched response independent, enriched control, impoverished response contingent, impoverished response independent, and impoverished control. Immediately postrearing Ss were exposed to three 5 min. free exploration periods of a novel situation over succesive days. Boli counts were recorded as an index of emotionality. Animals were then trained to acquisition criterion of a horizontal-vertical rectangle discrimination task in a two choice discrimination box apparatus. Following acquisition, a 30 d. period of succesive reversal methodology was employed. The number of days, errors, and persistent errors to initial acquisition, and the number of errors and successful reversals attained during the reversal phase were dependent measures denoting differences between early rearing histories. Results showed a discrepancy in emotionality data between the first and second runs. Closer examination revealed that fewer response contingent animals of the first run emitted boli than their second run counterparts. Findings were discussed with regard to the inadvertent introduction of an uncontrollable and unpredictable stressor. Perceptual enriched rearing was found to facilitate acquisition

of the perceptual discrimination task while contingent rearing conditions had very little influence. No differences were observed in the reversal phase. Results were taken as being consonant with Hebb's theory of perceptual organization and were discussed in terms of both perceptual enrichment and Seligman's learned helplessness theories.

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CHAPTER I

INTRODUCTION

Background Research

Enriched vs. Impoverished Rearing

Since Hebb (1949) reported that a group of rats reared by his children as pets performed better on a subsequent Hebb-Williams maze test than a comparable group of rats reared under standard laboratory conditions, a vast amount of research has been undertaken comparing learning performance of animals reared under enriched and impoverished conditions. Based upon initial findings, Hebb (1949) suggested that enriched experience during an early stage of development enhances problem solving ability at maturity, which he interpreted as intelligence.

The typical design comparing animals reared in enriched and impoverished conditions has been to raise one group of animals in an enriched environment where they are exposed to some level of supernormal stimulation. The enriched or free environment is a large enclosed cage where animals are reared, usually post-weaning, and contains a number of playthings, manipulanda and other objects such as tunnels, ramps, seesaws, mazes with which subjects (Ss) may interact. Food and water are usually present ad libitum in the apparatus. In contrast to Ss reared in an enriched environment, those

reared under impoverished or restricted conditions were deprived of some level of perceptual, social or locomotor stimulation, or some combination of these. Generally, the restricted environment has been a small, empty, solid walled cage where Ss were reared in isolation. If a control group was used it would usually consist of raising Ss in pairs in standard laboratory cages where they were exposed to the sensory input of 'normal' laboratory reared rats.

Considering the dissimilarities between typical enriched and impoverished environments it is easy to suspect that the probability of enhanced learning performance heavily favoured animals reared in conditions of supernormal stimulation. Tests for subsequent problem-solving ability following varying periods of differential rearing have usually produced unequivocal results indicating that animals reared in complex, free environments were superior to their restricted counterparts. However, most problem-solving behavior has been measured in the Hebb-Williams maze, as modified by Rabinovitch and Rosvold (1951), where deprived animals were trained to run from the start box through an empty enclosed field to a goal box where they were rewarded with access to solid or liquid reinforcement. After learning this initial task, a number of barriers were placed in the field so that different maze solving

problems were presented to Ss. The animal was required to take the most direct path to the goal box and reinforcement. When it made a deviation from the correct route an error was charged to the S. Hebb (1949) and other researchers using this technique assumed that animals making the least number of errors were the better problem-solvers and consequently the most intelligent.

Whether or not Hebb-Williams maze performance is a measure of intelligence has been questioned by several researchers. Zimbardo and Montgomery (1957) suggested that greater error scores attained by restricted animals may not be due to a deficit in intellect but to a greater exploratory tendency. Woods (1959) and Woods et al. (1960) added support to this notion. The former study found that restricted or impoverished animals made many errors in the maze after having entered the goal box, by returning to the enclosed field before consumption of reinforcement, thus suggesting that error scores may have been exaggerated due to "retracing". Therefore, differential error scores may be more attributable to exploration than intelligence. But when Woods (1959) eliminated retracing errors enriched Ss still made fewer errors, although errors made before entering the goal box may very well have been due to augmented exploratory tendencies on the part of restricted Ss. Woods et al. (1960) found a positive correlation

between activity levels in an open field apparatus, which is generally considered to be an acceptable and accurate measure of exploratory behavior (Denenberg, 1963) and subsequent error scores on the Hebb-Williams test. More recently, Smith (1972) excluded all retracing errors and found that enriched reared animals outperformed restricted Ss, thus eliminating a differential exploration explanation and supporting Hebbian theory that enriched perceptual experience early in life facilitated adult problem-solving performance. This also lent credence to the Hebb-Williams maze as a valid measure of this ability.

When other learning tasks have been employed, the effects of differential rearing were less clear. Wilson, Warren, and Abbott (1965) found that kittens reared postweaning in a complex free environment were superior in learning Hebb-Williams maze problems to Ss not exposed to this experience. But when tested on a brightness discrimination reversal task, enriched rearing did not facilitate learning. However, the use of succesive reversal methodology had previously been found to show differences in learning ability for rats (Krech, Rosenzweig, and Bennett, 1962), and for dogs (Melzack, 1962) when reared differentially indicating Ss exposed to enriched environments to be superior. Warren (1965) has shown that the ability to improve performance over a series of reversal tasks is positively

correlated to both phyletic status and developmental status within species. Therefore, Wilson et al., (1965) suggested that enriched rearing may be necessary for optimizing differences on spatial tasks such as the Hebb-Williams maze but was not necessary in measuring performance in apparati such as the Grice or other discrimination boxes. However, Wilson et al. (1965) confounded spatial and brightness dimensions and used a very lenient criterion to assess learning when testing Ss in the discrimination box. Exactly what is being measured by Hebb-Williams maze performance is equivocal, and whether "intelligence" is one aspect remains to be determined. However, it is capable of assessing problem-solving differences between enriched and restricted Ss.

Hebb's students were among the first to examine the effects of differential rearing during early developmental periods on adult learning. Hymovitch (1952) reared one group of Ss in free environment cages for 45 days (d.30-75) while another group was restricted to stovepipe cages. Then conditions were reversed for the two groups for another 45 days. One control group received free environmental experience throughout the study and a second was restricted to laboratory cages. Results indicated that Ss exposed to an enriched environment early in life were superior problem-solvers to those restricted during this period. Of equal

importance was that early exposure to a free environment resulted in equivalent learning ability to animals reared with both early and late experience. Animals that were subjected to early restriction did not differ significantly from those which were restricted throughout. These findings led Hymovitch (1952) to conclude that enriched perceptual experience should occur early in life to result in highly organized perceptual ability, including problem-solving at maturity and that the effects of early enrichment or deprivation might be long lasting and possibly permanent. Support for Hymovitch's conclusions are also seen in data presented by Forgays and Forgays (1952) where rats reared in free environments with playthings were superior Hebb-Williams maze learners to those reared in free environments without playthings, or to those exposed to some level of restriction. When all Ss were retested on a second series of maze solving problems, the rate of improvement was roughly equivalent for all groups suggesting that perceptual learning stemming from early rearing conditions might be permanent. Long term enhancement in maze learning due to brief periods of exposure (from 21-65 d.) to free environments has also been found be Denenberg, Woodcock and Rosenberg (1968), Denenberg and Morton (1962) and Forgays and Read (1962).

The Forgays and Forgays (1952) study indicates

that "playthings" or manipulanda were more directly responsible for enhanced problem-solving ability than was the size of the rearing environment. However, animals reared in open field environments with or without playthings were superior to all other groups which indicates that cage size, although not as important a variable in transfer of learning, does have an important effect on problem-solving ability. Animals reared in larger cages were found to use visual distance cues (those outside the test situation) for orientation more than animals reared under control or restricted conditions. However, when the apparatus was rotated, which changed S's perception of extrafield cues, there was a greater disruption in the performance of free environment animals than those reared in a restricted environment. Hymovitch (1952) reported similar findings and Brown (1968) showed that enriched rearing enhanced Hebb-Williams test performance only when the field was stationary, thus attributing differences to extrafield cues. This suggested that rearing in larger environments produced qualitative differences in perceptual behavior. Regarding locomotor activity, Syme and Hughes (1972) found an inverse relationship between cage size and emotional reactivity in an open-field apparatus. Results indicated that as cage size increased for rats reared in social isolation so did the frequency of

ambulation, square entries and rearing on their hind legs. Thus, isolation alone may not be entirely responsible for discrepant findings between socially reared and isolation reared groups. Perhaps the greater perceptual and locomotor opportunities available for group reared Ss due to cage size may in itself be a contributing factor.

The effects of enriched rearing on problem-solving behavior in the Hebb-Williams maze are virtually unquestionable. Although there are some exceptions (Aubrecht, 1974) they are few and not without criticism. Animals reared in large, complex environments are found to be distinctly superior to those from smaller and more sterile environments. This finding has been generalized to apparati other than the Hebb-Williams maze, such as discrimination learning apparati (Bingham and Griffiths, 1952; Krech, Rosenzweig, and Bennett, 1962).

As a result of early research employing differential rearing conditions, large cages containing a variety of playthings became a standard for what was considered an enriched environment. Later investigations examined the effects of exposure to specific stimuli on subsequent performance in a similar or related environment. Gibson and Walk (1956) studied the effect of early experience on later discrimination learning and found rats reared with triangular and circular

cutouts mounted on the cage walls were superior, when tested on a subsequent discrimination problem involving the same stimuli, to rats reared without these forms. Thus, preexposure to specific stimuli facilitated succeeding discrimination learning. However, the results of research stemming from the original Gibson and Walk study have been inconclusive. Support for the original study was reported by Gibson, Walk, Pick and Tighe (1958); Walk, Gibson, Pick and Tighe (1959); Forgus (1958, a,b); and Kerpelman (1965) but ambiguous results were found by Gibson, Walk and Tighe (1959); Walk, Gibson, Pick and Tighe (1958) and (1959); and Baird and Becknell (1962).

Several explanations have been postualted to account for discrepancies in this early experience effect. In discussing their initial findings Gibson and Walk (1956) suggested that exposure to the forms without differential reinforcement enhanced subsequent discriminability and this was accepted as supportive of perceptual "differentiation" theory as advocated by Gibson and Gibson (1955). This theory suggested that preexposure to stimuli which are 'to-be-discriminated' later was sufficient (with due limitations) for perceptual learning to occur and did not necessitate such constructs as reinforcement, drive reduction, etc. However, Kerpelman (1965) found that by removing the 'to-be-

discriminated' stimuli from the rearing environment for the 2 hr. daily feeding period, the effects of preexposure were greatly reduced in comparison to a group which was reared with, and where feeding occurred in the presence of the cage stimuli. Kerpelman suggested that differences found in the Gibson studies between preexposed and no exposure groups were not simply due to differentiation of stimuli on the part of Ss, but from the presentation of food, a primary reinforcer, which was nondifferentially introduced in the presence of the cage stimuli. According to Spence (1956), nondifferential reinforcement of two stimuli raises the excitatory tendency of both which gives preexposed animals a distinct advantage in learning the discrimination task faster due to a higher level of excitatory tendency. Thus, the results of Kerpelman (1965) are taken as being supportive of an enrichment rather than a differentiation theory of perceptual learning.

Further investigation into the qualitative differences existent in preexposure studies was reported by Anton and Bennett (1972). They found that hamsters reared with the 'to-be-discriminated' stimuli (three dimensional circles and triangles) performed better on a later discrimination task than nonexposed controls. However, a group given the opportunity to manipulate the

forms and thus receive tactual-kinesthetic feedback, showed no additional benefit in learning ability to a group which was allowed visual exposure but deprived of manipulation. In contrast, Gibson, Walk and Tighe (1959) reported that albino rats reared with three-dimensional stimuli outperformed a similar group raised with two-dimensional forms. This study was supported by Bennett and Ellis, 1968; Meier and McGee, 1959; and Forgus, 1955, and suggested that when exposed to three-dimensional forms the concomitant manipulation provides Ss with more information than is available in a two-dimensional, strictly visual environment and therefore lends itself to a tactual-kinesthetic interpretation (see Bronfenbrenner, 1968). The results of Bennett, Rickert and McAllister (1970) with hooded rats and Anton and Bennett (1972) with hamsters indicate that for animals with pigmented irises the exposure to and opportunity to manipulate the preexposed forms was of no greater benefit than exposure to two-dimensional stimuli on a subsequent discrimination task. It is therefore quite apparent that the visual system of the animals being studied must be taken into consideration before results can be considered to support a particular hypothesis. In the original Gibson and Walk (1956) study, albino rats were reared with three-

dimensional forms but in several of the studies stemming from this work, only two-dimensional stimuli were employed, confounding the author's interpretation.

The above studies have all made a significant contribution to the field concerning the effects of qualitative differences in early rearing environments, whether these differences are of a general (i.e. enriched vs. impoverished rearing) or of a more specific nature (i.e. transfer effects of rearing with the to-be-discriminated stimuli). Typically, problem-solving behavior subsequent to enriched early experience has been tested in the Hebb-Williams maze or other maze-learning apparati, while discrimination learning of specific stimuli has been carried out in a Grice box apparatus. Very little deviation from this methodology has been undertaken. However, both enriched rearing and rearing with specific stimuli appear to produce qualitative differences in learning ability in adulthood.

Critical Periods

Given that enriched experience does influence later problem-solving ability, a meaningful question concerns whether or not critical periods exist during which enriched exposure is necessary to enhance later learning. Hebb (1949) suggested that such exposure should take place before Ss reach maturity in order to

be most effective. Evidence for this statement was provided by Hymovitch (1952). More recently, Forgays and Read (1962) exposed rats to free environments during weeks 1-3, 4-6, 7-9, 10-12, and 13-15 in an attempt to determine the extent of exposure to an enriched environment that was necessary to produce superior problem-solving ability in adulthood and when specifically, during development should this exposure occur. Results indicated that all groups except those exposed during weeks 13-15 (when Ss are considered mature) performed better on a Hebb-Williams test than a group of control Ss which were nonexposed. The most effective period facilitating adult problem-solving ability was the three week period immediately following weaning (d.21) which led Forgays and Read (1962) to conclude that a 'critical period' did exist but the amount of exposure necessary to facilitate learning was not determined. Denenberg, Woodcock and Rosenberg (1968) supported these findings. They found that enriched rearing immediately after weaning had a greater influence on problem-solving behavior in adulthood than the same experience before weaning. But even preweaning enrichment was sufficient to result in better maze learning than nonexposed control groups. The critical feature of this study was that animals were not tested until almost a year

following termination of early exposure, which suggests the permanence of early enrichment effects.

Although much research has been undertaken, the concept of a critical period remains somewhat ambiguous. Denenberg (1962) suggested that a critical period was a function of the intensity of stimulation and that there were as many critical periods as there were dependent and independent variables. In further investigating this problem, Nyman (1967) found that 10 days of free environmental experience was most effective for spatial discrimination learning if it occurred between days 50-60, thus suggesting a critical period. However, he found that more experience at a less "critical" age may be as effective as less experience at a more "critical" period. Incidentally, Nyman's (1967) study was one of the few studies to raise animals in enriched and restricted environments then test them using a visual discrimination task as well as maze learning. Visual discrimination results were insignificant but a very brief rearing period had been employed.

The term 'critical period' appears to be a misnomer. There is no period where exposure must occur in order for Ss to solve problems. The difference in problem-solving ability is one of degree and animals will usually learn the succesful solution regardless

of rearing conditions. Perhaps a period of 'efficacy' or greater 'receptivity' would be more applicable. What appeared to be of greatest significance with regard to critical period research was that experience before maturity was more effective than the same experience after maturity which confirms the original finding of Hymovitch (1952).

Social Rearing

The forementioned research indicated that many influential variables must be considered when studying the effects of exposure to a free environment. However, many problems still exist in this line of research and some of them have been virtually ignored. In the laboratory setting an enriched environment was a large cage containing other Ss and playthings. These animals were typically compared on a learning-performance task to a group that had been reared in an environment that was both perceptually and socially sparse. Differential performance was then attributed to exposure to a free environment. Research has shown that both cage size and the presence of objects influenced the free environmental effect but the social factor was one that was too often overlooked. Gardner et al. (1975) isolated the effects of social enrichment (the sight and tactile presence of other rats) from inanimate perceptual

enrichment. Their study employed four groups;
1) perceptually enriched - socially enriched (PE-SE),
11) perceptually enriched - socially impoverished (PE-SI),
111) perceptually impoverished - socially enriched (PI-SE),
1V) perceptually impoverished - socially impoverished (PI-SI)
to ascertain the role of perceptual and social enrichment in improving learning ability. After rearing in their respective environments animals were tested on a one trial, step-down passive avoidance task. Results indicated that SE Ss showed maximum retention after a 24 hr. interval while SI Ss showed the least. However, the perceptual environment was a contributing factor as PI-SI showed no evidence of learning at all. To determine why SI Ss were inferior learners and the involvement of memory, a second study involving the same passive avoidance task as in the first study was carried out but following footshock Ss were given ECS (an amnestic agent) at 0.5, 10 or 60 sec. intervals. Retention testing occurred 24 hr. later. The data indicated that SE Ss showed a standard gradient of retrograde amnesia with better retention at 60 sec. than at the 10 sec. interval, while SI Ss showed no difference. For SI Ss the amnestic effects of ECS were the same at 60 and 10 sec. intervals which led Gardner et al. to conclude that rearing in a socially impoverished environment

may slow down the memory consolidation process. This interpretation lends support to that of Greenough, Madden and Wood (1972) who found that mice reared in impoverished and standard (two per cage) conditions weren't able to store information as fast as enriched reared animals. Thus, Gardner et al. (1975) suggested that facilitated problem-solving ability observed in animals reared in enriched environments may have been due to differential development of specific storage and retrieval mechanisms. Perhaps such disparate rearing environments might produce memory disruptions mediated by alteration of specific brain mechanisms.

Cerebral Effects of Early Experience

Further evidence suggesting neurological change due to early rearing environment was presented by Bennett, Diamond, Krech and Rosenzweig (1964); Krech, Rosenzweig and Bennett (1966); Rosenzweig and Bennett (1972); and Cummins, Livesey, Evans and Walsh (1977). For an excellent review see Rosenzweig, Bennett and Diamond (1972); and Rosenzweig, Bennett, Krech, and Diamond (1968). In summary, these studies suggest that rearing in a socially and perceptually enriched environment will result in a) a heavier cerebral cortex, b) a thicker cortex, c) greater total acetylcholinesterase (ACHE) activity but less activity per unit

weight, d) greater cholinesterase (CHE) activity, both for total and per unit weight, e) more glial cells, f) larger cell bodies and nucleii, g) fewer synapses but synaptic junctions which are 50% wider than Ss reared in an impoverished environment, h) more dendritic spines, and i) a greater cortex-subcortex weight ratio. However, Rosenzweig et al., (1968) reported that neither social rearing in a relatively simple environment, nor isolation rearing in a complex environment was sufficient to produce cerebral changes of the magnitude typically found when groups of animals were exposed to complex environments. Thus, it is apparent that the social variable is an important one in early enrichment studies producing neurological change. This variable may also influence problem-solving behavior.

Research over the last 30 years involving environmental enrichment and deprivation has provided a wealth of knowledge with regard to the effects of differential rearing conditions on learning and problem solving ability, changes in cholinergic enzyme systems, exploratory behavior, memory and emotionality. We are able to state unequivocally that environmental enrichment produces animals that are superior problem-solvers at maturity.

Response Contingent vs. Independent Rearing

Numerous variables such as the size of the rearing environment, the age of exposure to it, the duration of exposure, the visual system of the Ss, the perceptual and tactile complexity, the social condition and the type of task employed to assess possible differences, have great influence on learning ability and must be properly controlled to assure accurate interpretation of the findings. However, one potentially important variable, and one that has never been studied in the context of enrichment-deprivation studies, is the dimension of controllability. The standard enriched environment was not only a large open field containing other animals but also contained many objects or playthings over which Ss were able to exert some control. In contrast a S reared in isolation in a small, solid-walled cage devoid of enriching "toys" was deprived of the opportunity to control his environment to the same extent that enriched reared Ss were able to control theirs. This is not to say that an animal reared under conditions of deprivation doesn't learn that a given response will produce an outcome, but there are restricted numbers of responses and outcomes available in comparison to an animal reared in an environment composed of a variety of controllable events,

and objects. In an enriched environment various items are placed throughout to provide Ss with abundant perceptual and tactile experience. However, Ss not only look at these objects but push them, pull them and chew them. If a ball is available within the rearing environment, Ss learn after very few trials that every time it pushes the ball it moves forward or that every time it runs in a running wheel the wheel turns. Socially enriched animals also learn that by interacting with peers, a particular response on their part (i.e. jumping on a cagemate) is likely to be reciprocated. Enriched rearing provides Ss with the opportunity to learn that their responding was effective. In other words, Ss may develop a concept that certain environmental outcomes are contingent upon responding.

According to Seligman (1975) a sense of environmental "mastery" develops when infants are exposed to a multitude of circumstances where synchronies exist between their responding and outcomes. However, if, during the same period of infancy, independence was experienced between voluntary responding and outcomes, the organism was capable of learning response - outcome independence. This learning of response - outcome independence can interfere with subsequent learning and when it does occur is referred to as "learned helplessness"

(Overmier and Seligman, 1967).

What is meant by 'learned helplessness' is simply that an organism can learn that the probability of an outcome (O) occuring is equivalent whether or not a response is made. This can be represented by the equation $p(O/R)=p(O/\overline{R})$ which means that the probability of an outcome contingent upon the organism's response is equal to the probability of it's noncontingent (or independent) occurrence. Thus, exposing animals to events over which they had no control can interfere with later learning when outcomes were contingent upon responding.

The classical study demonstrating the effects of uncontrollable aversive events interfering with subsequent learning ability was undertaken by Overmier and Seligman (1967). In this study dogs were strapped into a Pavlovian harness and had electrodes attached to their feet in order that a 6 ma. shock could be delivered for a 5 sec. duration. On the first day Ss were given 64 unsignalled and inescapable shocks which were presented randomly. No response S made would terminate shock. On the following day they were given 10 trials in a two-way shuttlebox apparatus where S had to jump over a barrier to escape or avoid shock. The CS-UCS interval was 10 sec. If the dog jumped the barrier during this interval the CS was terminated and the shock was succesfully avoided.

However, if S failed to jump during this interval the CS remained on and shock was applied until S did jump or until 60 sec. had elapsed when the trial was terminated. Results indicated that all dogs exposed to inescapable shock were significantly slower in escaping and showed many more failures to escape than a control group which was not exposed to the pretreatment condition. Overmier and Seligman (1967) concluded that the deprivation of control over environmental events interfered with subsequent learning ability.

Since this preliminary research, the learned helplessness design has been somewhat modified to be more precise. The 'triadic design' involves one group that receives as pretreatment, an outcome that is contingent upon some response; a second group is yoked to the first and receives identical outcomes but has no response available to control or modify outcomes; and a third group receives no pretreatment. The employment of the triadic design has allowed repeated demonstration that it was not shock itself that resulted in failure to escape when such escape or avoidance was possible, but the inability to control the shock (i.e. Maier, 1970). That response-independent electric shock administered to dogs and rats interferes with subsequent escape-avoidance learning in relation to groups exposed

to escapable shock or given no exposure is a highly stable phenomenon (e.g. Looney and Cohen, 1972; Maier, 1970; Maier and Testa, 1975; Seligman and Beagley, 1975; Seligman and Maier, 1967; and Seligman, Rosellini and Kozak, 1975). It was the learning of response-outcome independence that was believed to interfere with learning to escape or avoid shock in a novel situation (see Seligman, 1975; and Maier and Seligman, 1976 for an excellent review.).

In contrast to animals which have been exposed to inescapable and uncontrollable shock, those that have received equivalent amounts of shock they could escape and control appear to be immunized against the disruptive effects of subsequent inescapable shock. Experience with escapable shock effectively immunized animals against the inescapable shock which occurred at a later period and was of sufficient quantity and intensity to have produced helplessness in untreated Ss (Hannum, Rosellini and Seligman, 1976; Looney and Cohen, 1972; Seligman and Maier, 1967; and Seligman, Rosellini and Kozak, 1975). It appears that experience with control over shock termination prevents helplessness from occurring just as experience with uncontrollability produces interference.

Not only did exposure to inescapable and uncontrollable events retard learning in a novel situation

where the opportunity for Ss to make an effective response existed, but if the exposure was prolonged it produced several concomitant deficits. Seligman's (1975) theory of learned helplessness indicated that the expectation of an outcome independent of responding, 1) undermined the organisms motivation to initiate voluntary responding that could control the outcome of other events; 2) produced a cognitive deficit which interfered with learning that subsequent responding was successful; and 3) if exposure was prolonged would produce an emotional deficit accompanied by augmented anxiety.

Learned helplessness can be observed in any species that is given prolonged exposure to uncontrollable aversive events and which is capable of learning response-outcome independence. Uncontrollability has produced helplessness not only in dogs and rats but with cats, pigeons, fish, infrahuman primates and man. For example Hiroto and Seligman (1975) found that humans pretreated with unsolvable, solvable, or no discrimination problem differed in their ability to escape loud noise in a subsequent situation when a response in a finger shuttle box was made available. They found that people given no discrimination problem or those for whom the problem had been solvable escaped the loud noise with ease while those exposed to

unsolvable problems sat passively and accepted the noise. The investigators suggested that an unsolvable discrimination problem was analogous to inescapable shock in that both were uncontrollable. This research extends the generality of the helplessness effect within an aversive context.

Further investigation with rats exposed to inescapable shock has indicated that the interference effect generalizes from aversive to appetitive situations. Rapaport and Maier (1978) found that animals receiving inescapable shock showed lower levels of dominance to rats which had received either no shock or escapable shock in a food competition situation under 48 h. food deprivation. Suggestions that differential results were due to either decreased hunger or slower running speed to the food cup were ruled out. Further study of the generalizability of helplessness phenomena from an aversive to an appetitive situation was reported by Rosellini (1978). In this research rats exposed to inescapable shock showed heightened interference in the acquisition of food contingent operant responding than Ss exposed to either escapable or no shock conditions. In addition, the introduction of a 1 sec. delay of reinforcement produced much greater interference than when reinforcement was immediately delivered. Thus,

exposure to inescapable shock produced subsequent interference with appetitive operant learning.

There is unambiguous evidence to suggest that pretreatment in an aversive context interferes with performance in similar and dissimilar learning situations. Exposure to uncontrollable appetitive reinforcers has also been found to impair responding for reward. Seligman (1975) reported unpublished research of Seligman, Meyer and Testa where groups of rats had pellets dropped through a hole in the roof of their cage completely independent of responding. When placed in a novel situation where food delivery was made contingent upon a response (bar press) the authors noted that the more free food Ss had received during pretraining the longer they required to attain an appetitive instrumental response. Similar research reported by Welker (1976) suggested an appetitive analogy to learned helplessness studies. However, the experimental design was badly flawed and made interpretation of results somewhat ambiguous. Welker (1976) made grain presentation to RI pigeons independent of their responding but failed to yoke RI Ss to their RC counterparts. Thus, differential temporal contiguity of grain presentation may have existed between the two groups. Secondly, C Ss were not exposed to the same number of experimental sessions

as were RC and RI animals. Finally, and perhaps the most significant flaw was that preliminary training and testing sessions were conducted in the same experimental chamber whereas typical learned helplessness studies usually administer preliminary shock in a chamber quite different from the testing chamber. If Welker's results could be replicated using more precise experimental methodology they would be of great relevance. Wheatley, Welker and Miles (1977) conducted such an experiment. Twelve rats were placed singly on d. 45 into one of three preliminary training chambers. One group of Ss had to make contact with a food cup in order to receive delivery of a food pellet. A second group, yoked to the first, received a response-independent pellet each time it's yoked counterpart responded. The control group received the identical number of pellets as it's corresponding response-contingent and response-independent mates, but the pellets were delivered en masse once daily. Animals remained in their respective environments 24 hr. daily for 15 days, when they were removed and food deprived for a 24 hr. period. They were then placed in a novel test chamber for a 2 hr. period until each S had reached an acquisition criterion of 50 bar press responses on a CRF schedule. It should be noted that during pretraining a food cup - contacting response was reinforced

on a CRF schedule on d. 1, FR 5 on d. 2, and FR 25 from d. 3-15. Results indicated that the response-contingent (RC) group acquired the barpress response faster than the control (C) group which in turn was faster than response-independent (RI) Ss. These findings are very important to learned helplessness theory and extend the generality of the interference effect to situations where deprivation of appetitive control leads to retardation in the acquisition of effective appetitive responding in a novel situation. This study also contained methodological problems that render these results less conclusive than they might at first appear. First, RC Ss were reared in an environment where food delivery was contingent upon approaching a food cup. When later tested in a different apparatus, a very similar response was required of these Ss. They now had to approach a lever which was located only 11 cm. from the identical food cups from which food delivery was previously made contingent. The behavior of RC Ss would obviously have been drawn to the general vicinity of the food cup and this may have facilitated barpress acquisition. Second, the study employed a testing apparatus which was different from the pretraining apparatus but several very important dimensions remained identical. Food cups, the delivery of a 45 mg. pellet, and the accompanying sound of the pellet dispensery system were unchanged from pretraining to testing.

In order to make interpretation of appetitive to appetitive interference phenomena more significant, the employment of a testing situation less similar to the pretreatment environment should be employed.

Given the problems stated above, the results of Wheatley, Welker and Miles (1977) are still of great importance. According to learned helplessness theory, animals reared for only 15 days in response-independent environments were slower in acquiring an appetitive barpress response because they learned the independent relationship between food delivery and their own behavior. On the other hand Ss reared for an equivalent period in RC environments learned a response-reinforcer contingency which enhanced similar learning in a novel situation. Of relative importance in this study was that RC animals had control over only one event that RI Ss were deprived of. What would be the consequence if RC Ss had been allowed control of more than just feeding; i.e. responding to attain water, lighting, heat, or other stimulation? Would the degree of control intensify the "mastery" of RC in relation to RI Ss or would RI Ss simply become more helpless as more uncontrollable and unpredictable events occurred independently of their behavior? These questions are important and must be seriously considered in studying the effects of contingent environmental rearing conditions.

The helplessness research reported above provides evidence of the generality of the interference effect. Prior exposure to response independent events produced a deficit in subsequent learning ability not only when the uncontrollability was experienced in an aversive setting and then tested in a similar aversive situation, but also generalized from aversive to appetitive, and appetitive to appetitive learning tasks. Goodkin (1976) has extended the generalizability in learning from an appetitive to an aversive situation. Animals trained to perform an instrumental response for food pellets were superior learners in a later escape/avoidance situation than were Ss which received independent food delivery. Of equal importance was the finding that rats initially trained on an appetitive task acquired the escape/avoidance task at an equivalent rate to animals given prior exposure to contingent escape/avoidance and then tested on a task involving the same aversive stimulation but a different operant response. Goodkin (1976) has shown conclusively that rats are able to learn the relationship between responding and it's consequences and once such a relationship was acquired it had a strong influence on subsequent learning. Thus, it is apparent that, within limits, the effects of contingent and independent learning are generalizable to a wide range of succesive situations.

The Present Study

Given the above findings on learned helplessness, we return to our original question: To what extent is enhancement of learning due to earlier enrichment of the environment an indication that an organism has learned response-outcome contingencies? Is an enriched environment enriched due to the presence of a variety of objects or is it enriched because of the presence of the objects in conjunction with the organisms ability to interact with them? Is an impoverished environment impoverished because of the lack of such objects or is it impoverished because the organism exposed to it is deprived of control over it? Seligman (1975) has suggested that the placing of objects in an enriched environment was unlikely to produce the benefits of enrichment if Ss were deprived of the ability to control or manipulate them. However, this suggestion does not fare well with the findings of Hymovitch (1952) who found that Ss reared in small mesh cages within a larger free environment performed as well on Hebb-Williams maze problems as Ss given free run of the whole environment. This finding tends to preclude the necessity of determining the possible contribution of the dimension of control. However, Forgays and Forgays (1952) found somewhat discrepant results to those of

Hymovitch. Rats reared in small mesh cages within the larger free environment did not perform as well on subsequent problem-solving tests as reported by Hymovitch (1952). They did however, perform better than Ss reared in mesh cages within a free environment devoid of playthings. This indicates that perceptual learning was an obvious important component, but why did they not perform as well as their free environment counterparts? If Seligman (1975) is correct in his assumption, the differential results were due to deprivation of control on the part of mesh caged animals.

In the event that rats reared in mesh cages within the larger free environment are deprived of control over response-reinforcer contingencies, the results of typical enrichment-impoverishment studies may very well have overlooked the controllability dimension when translating results. Few studies have been undertaken specifically examining the effects that early environmental control may have on later behavior. A group of rats exposed to enriched rearing conditions encounters a situation of supranormal stimulation. Each individual within the group perceives and interacts with the playthings provided by the experimenter. In addition, it also experiences synchronous relationships with it's cagemates. The rat reared under conditions of depri-

vation on the other hand, is usually reared in isolation in a subnormal perceptual environment lacking objects. What must be determined is whether deprivation of stimulation is totally attributable to perceptual learning deficits or whether control over that stimulation has an effect. In other words, does an organism which is exposed to early control over environmental events develop a sense of environmental mastery that may generalize to novel situations, and is an organism which is deprived of synchronies between it's responses and outcomes rendered helpless?

Several recent studies suggested that this may be a distinct possibility. Joffe, Rawson, and Mulick (1973) reared rats housed four per cage in RC or RI environments for 40 days (d.21-61). During this period RC Ss were able to control delivery of food, water and lighting conditions by pressing an appropriate response lever. Animals in the RI group had the same levers available and received identical deliveries of food, water and changes in lighting as RC Ss but independent of their behavior. At approximately 62 days of age Ss were removed from their respective rearing environments and tested for emotionality in an open field apparatus. Results indicated that rearing in RC environments produced less emotional animals as measured by

activity and defecation scores. Joffe et al. (1973) made no attempt to extend the findings to a learning situation.

Wight and Katzev (1977) employed the same methodology as Joffe et al. (1973) where the delivery of food, water and light change were controllable for one group and uncontrollable for a second group. Rats were reared 6 Ss/cage in either environment from birth to d. 65 when they were removed and tested on a signalled escape-avoidance task in a two-way shuttlebox. Animals reared in RC environments were found to acquire escape-avoidance criteria significantly faster than RI Ss. These results showed that learned helplessness was also capable of affecting subsequent learning ability in an aversive situation when pretreatment involved appetitive control. Wight and Katzev (1977) suggested that the degree to which an organism could control early environmental events may have a profound effect on long-term ability to learn response-outcome contingencies.

Related findings of uncontrollability were demonstrated in a discrimination learning situation by Bainbridge (1973). In an attempt to determine whether or not early experience with an unsolvable problem would affect later learning ability rats were given

experience from 50-60 days of age with either a solvable or unsolvable black-white discrimination task in a visual discrimination apparatus. A third group was non exposed. Bainbridge (1973) found that early experience with an unsolvable problem (i.e. where food reward was independent of S's responses and stimuli) led to a significant deficit in learning ability not only in a situation which was similar to the early experienced unsolvable problem but also on problems selected from general tests of animal intelligence. Early experience with a solvable problem led to superior performance in the same situations. Bainbridge (1973) concluded that exposure to an unsolvable problem discourages hypothesis testing in the rat (i.e. motivation deficit) and may ultimately lead to a lasting generalized learning deficit (i.e. cognition).

The number of studies exposing animals to contingent rearing environments are few, but evidence has been presented which suggests that early control over environmental events enhances later learning ability in both appetitive and aversive situations. Similarily, deprivation of early control produces interference with learning. The preliminary findings of response dependent and independent rearing environments is analogous to findings in enriched-impoverished

rearing environments. Rearing in both enriched and response contingent environments facilitates subsequent learning ability while rearing in impoverished and response independent environments impedes this ability. The present research has been designed to examine the dimension of controllability in conjunction with the early rearing environment of the organism. By standardizing previously cited significant variables such as cage size and social rearing conditions this study attempted to isolate the contributions of two major rearing variables; enrichment vs. impoverishment and response contingency vs. response independence.

Animals were reared in one of six environments corresponding to the 6 conditions of a 2X3 factorial design (2 levels of rearing environment and 3 levels of contingencies). The duration of exposure to the pre-treatment condition (35 d.) included a period shown to be sensitive to the experimental treatment (Nyman, 1967) as well as conforming to periods of environmental experience found in similar studies, where differential results due to rearing conditions had been obtained. Upon removal from respective rearing environments (d.60) Ss were housed individually and placed on a 23.5 hr. water deprivation schedule to facilitate running for a 10% sucrose solution reinforcer.

During adaptation to the discrimination box testing apparatus, Ss were initially given 3 succesive days during which they were free to explore the entire apparatus for 5 min. Fecal boli counts were taken as this had previously been found to be an index of emotionality. Denenberg and Morton (1962,a), Forgus (1954) and Woods et al. (1960) found that among rats reared in free enriched or restricted environments, the restricted Ss usually proved to be more emotional. Similarly, Joffe et al. (1973) recently found that rearing in response-independent environments produced more emotional animals than response-dependent rearing.

After completion of an adaption period, perceptual discrimination learning ability of all Ss was assessed in a discrimination learning apparatus. Results of the Bainbridge (1973) study indicated that a discrimination learning situation was amenable to prior experience with response contingent and independent learning. Rats which had received training on a solvable, and thus response contingent, black-white discrimination task were superior in problem-solving ability on a similar discrimination learning task employing upright and inverted triangles, than a group of animals for which the black-white problem had been unsolvable, and therefore independent of voluntary responding. More

important however, was the finding that early experience with an unsolvable problem not only led to a deficit in problem-solving ability in a similar situation, but generalized to problems selected from the Hebb-Williams test for animal intelligence and to a spatial modality in a multiple unit maze. This deficit lasted over a 20 d. period and influenced performance on tasks quite dissimilar from that on which the unsolvable problem was experienced. The Bainbridge (1973) findings support Seligman's (1975) theory that the response independence or uncontrollability experienced by Ss exposed to the unsolvable problem interfered with later learning ability and suggest that a discrimination learning situation might be one which would allow differences due to both perceptual and contingent rearing conditions to be exhibited.

Support for Bainbridge (1973) was provided by Mullins and Winefield (1977) who found that prior experience with a solvable black-white discrimination problem not only led to superior performance on a horizontal-vertical task in comparison to a group for which the problem had been insoluble , but also reduced the interference effect when these rats were exposed to an insoluble problem. The authors suggested that animals exposed to a soluble problem were 'immunized'

(Seligman, Rosellini, and Kozak, 1975) against the interference effect found when Ss had received prior exposure to insolubility.

In the present experiment each animal was run 12 trials/day on a simultaneous discrimination task. Specific visual stimuli were paired with entry to the correct goal chamber and 10 sec. access to reward. For half the Ss a black, horizontal rectangle on a white background was S^D and a black, vertical rectangle on a white background, S^{Δ}. Stimulus conditions were reversed for the other half. Animals were run on a series of spaced, forced choice trials where position of stimuli were determined randomly, to a criterion of 22/24 correct trials over a 2 day period. The day following acquisition of the original discrimination, the positively and negatively reinforced stimuli were reversed and Ss received 30 days of succesive reversal methodology. Exposure to enriched environments had previously been found to facilitate reversal learning in rats (Krech, Rosenzweig, and Bennett, 1962) and dogs (Melzack, 1962) although Wilson et al. (1965) failed to find it with cats. Wong and Judd (1973) suggested that succesive reversal methodology was most likely to reveal group differences when data were analyzed in terms of number of reversals attained within a fixed

number of test trials. Since the effects of rearing in response-contingent or independent environments had not been previously assessed in relation to perceptual discrimination learning ability, the reversal learning period was used as a secondary measure of learning ability. If animals reared in RI environments were influenced by interference it may be argued that when faced with reversing previously reinforced stimuli, they would not perform as well as RC animals who may have developed a sense of environmental mastery.

During the initial discrimination learning phase performance was measured in terms of number of days and errors to criterion, and the number of persistent errors made to criterion. For the succesive reversal stage differential performance was determined by the number of reversals completed and the total number of errors during the 30 day period.

Hypotheses were generated from the numerous studies conducted over the past 30 years concerning the effects of free enriched rearing or deprivation rearing on subsequent learning performance, as well as from recent literature expounding the interference effect on learned helplessness (Seligman, 1975). If perceptual enrichment was directly responsible for improved learning ability in enrichment-impoverishment studies,

animals reared under conditions of enrichment were expected to reach acquisition criterion faster and with fewer errors than animals reared in perceptually impoverished environments. However, if rearing in response-independent environments produced interference with learning in another situation, RI animals were expected to acquire the discrimination task slower and with more errors than RC Ss because they would be somewhat retarded in their motivational and learning abilities. Control animals were expected to perform at an intermediate level between RC and RI Ss.

If the above stated hypotheses were correct in their prediction, these effects should carry over to the succesive reversal phase of the study.

For the emotionality variable, similar results would be predicted. If enriched rearing reduces emotionality then animals reared under conditions of deprivation would be expected to emit more boli during the adaptation period. On the other hand, if rearing in RC environments reduces emotionality, RI animals should have a greater boli count with control animals at an intermediary level.

CHAPTER II

METHOD

Subjects

Seventy-two male Wistar rats from the University of Windsor breeding colonies served as Ss. The study was run in two replications of 36 rats. Six litters of 6 Ss were weaned at 21 days of age and were 25 ($\pm$ 1) days old when introduced into their respective rearing environments. Subjects had ad lib access to food and water from days 21-25. One S from each litter was assigned to one of 6 colony environments.

Apparatus

Rearing Environment. Six free environment colony cages were used of which three were perceptually enriched (E) and three were perceptually impoverished (I). Since each cage housed six Ss per replication, all were considered socially enriched. All rearing environments were 1.22 X 0.92 X 0.51 m. with a $\frac{1}{4}$" (0.06 cm.) hardware cloth floor, a $\frac{1}{2}$" (0.12 cm.) plywood back and side walls which were painted flat grey.

Within each E and I condition one colony cage was response contingent (RC), a second was response independent (RI), and a third served as a control (C) cage.

Both RC cages (ERC and IRC) had four response manipulanda available; two controlled the delivery of food and two the onset of a 2.5 sec. burst of light. A Lehigh Valley pellet dispenser was located midway on each side wall and delivered 45 mg. Noyes pellets to a Petri dish (10 X 2.2 cm.) bolted to the floor adjacent to the dispenser outlet tube. Each dispenser was activated by a response lever located 6 cm. from the floor and 4 cm. from the pellet delivery tube. One lever was a standard Lehigh Valley model and the other was a Burgess microswitch modified with a rectangular piece of clear plexiglass mounted to the metal shaft, to serve as a bar. The fabricated microswitch lever required less force for activation than the Lehigh Valley lever. Response contingent cages were also equipped with one Lehigh Valley omnidirectional ceiling rod and one modified Burgess microswitch, each of which would activate a pair of 24 V. incandescent cue lamps (0.12 cm. diameter). One lamp of each pair was capped with a green the other with a yellow diffused-light jewel cap. The omnidirectional switch was modified by inserting 3/16" (.05 cm.) dowel into the hollow metal shaft so that it hung 7 cm. directly in front of the cue lamps, to a level 10 cm. from the cage floor. The Burgess microswitch was modified by inserting a

thin wire through a hole drilled in the tip of the metal shaft. Animals were able to activate the switch by pulling downward on a 5 cm. piece of ¼" dowel which was connected to the lower end of the wire that also hung to a level 10 cm. from the cage floor. When activated, each switch would turn on it's respective pair of cue lamps; 1 pair located 30 cm. from each end of the rear plywood wall. The lower lamp of each pair was situated 17 cm. from the cage floor, the upper lamp 10 cm. directly above the lower. Each pellet dispenser and pair of cue lamps in an RC cage was wired in parellel with a dispenser and pair of cue lamps located in exactly the same position in the yoked RI cage.

The RI cages were physically identical to their respective RC cage except that food delivery response levers were situated 25, rather than 4 cm., from the pellet delivery tube in order to prevent the establishment of superstitious behavior. The four response levers in RI cages were nonfunctional, consequently, animals in these cages had levers available and received equivalent food and light deliveries as did RC Ss, but had no control over their occurrence.

The C cages were physically identical to respective RI cages but were not equipped with pellet dispensers. Animals were fed once daily through a food delivery tube situated in the same location as in

RC and RI cages. In order to accommodate the amount of pellets, Petri dishes were substituted with 23 cm. diameter pyrex pie plates. Cue lamps were present but nonfunctional.

In addition to the forementioned equipment, the three enriched environments were supplied with a number of standard objects; a plywood platform painted flat grey (10 cm. wide) ran the entire length of the front wall of the cage, 28 cm. above the cage floor; a ramp (10 cm. wide) covered with $\frac{1}{4}$" hardware cloth, to provide footing, was attached to the platform; a large, clear pyrex tunnel was elevated 5 cm. from the cage floor in a clear plexiglass frame; a cake tin (25 X 6 cm.) half filled with cat litter; a six unit maze (46 X 32 X 15 cm.) which contained one blind alley and two entrances, painted black and white and covered with a clear plexiglass top; five wooden children's blocks of various colours bolted to the rear wall between the two pairs of cue lamps; a circular metal cut-out painted blue and bolted to a side wall; a day-glo pink Indian rubber ball; a tin can open at one end; and an empty wire spool. The objects remained unchanged throughout the study and were bolted to either the cage walls or floor to prevent manipulation by Ss. Brown and King (1971) suggested that the variety of stimulus change during

rearing enhanced later learning with rats. However, Ivinskis and Ivinskis (1976) have demonstrated that rearing one group of rats in an enriched environment where objects were changed weekly produced no additional gain in relation to a group reared with objects unchanged. They concluded that once initial enrichment was presented, added change had no effect on learning ability. Therefore, there appears to be no necessity to change playthings in the present study. (See Photo 1).

The three perceptually impoverished environments were devoid of playthings. The only objects in these cages were the four response levers, four cue lamps and the two food dishes.

The room in which the cages were housed was maintained on a 12 hr. light/dark cycle (8 a.m. to 8 p.m. light) and was dimly illuminated by 6 overhead lights. In order to prevent animals in any given environment from observing those in another, the front hardware cloth wall faced the brick wall of the colony room. Two water bottles per cage were available ad libitum. Drinking spouts protruded through the hardware cloth wall to a level 6 cm. from the floor.

All cages stood on legs 7 cm. above the floor to facilitate cleaning. Experimental variables were recorded automatically via standard relay circuitry located in an adjoining room.

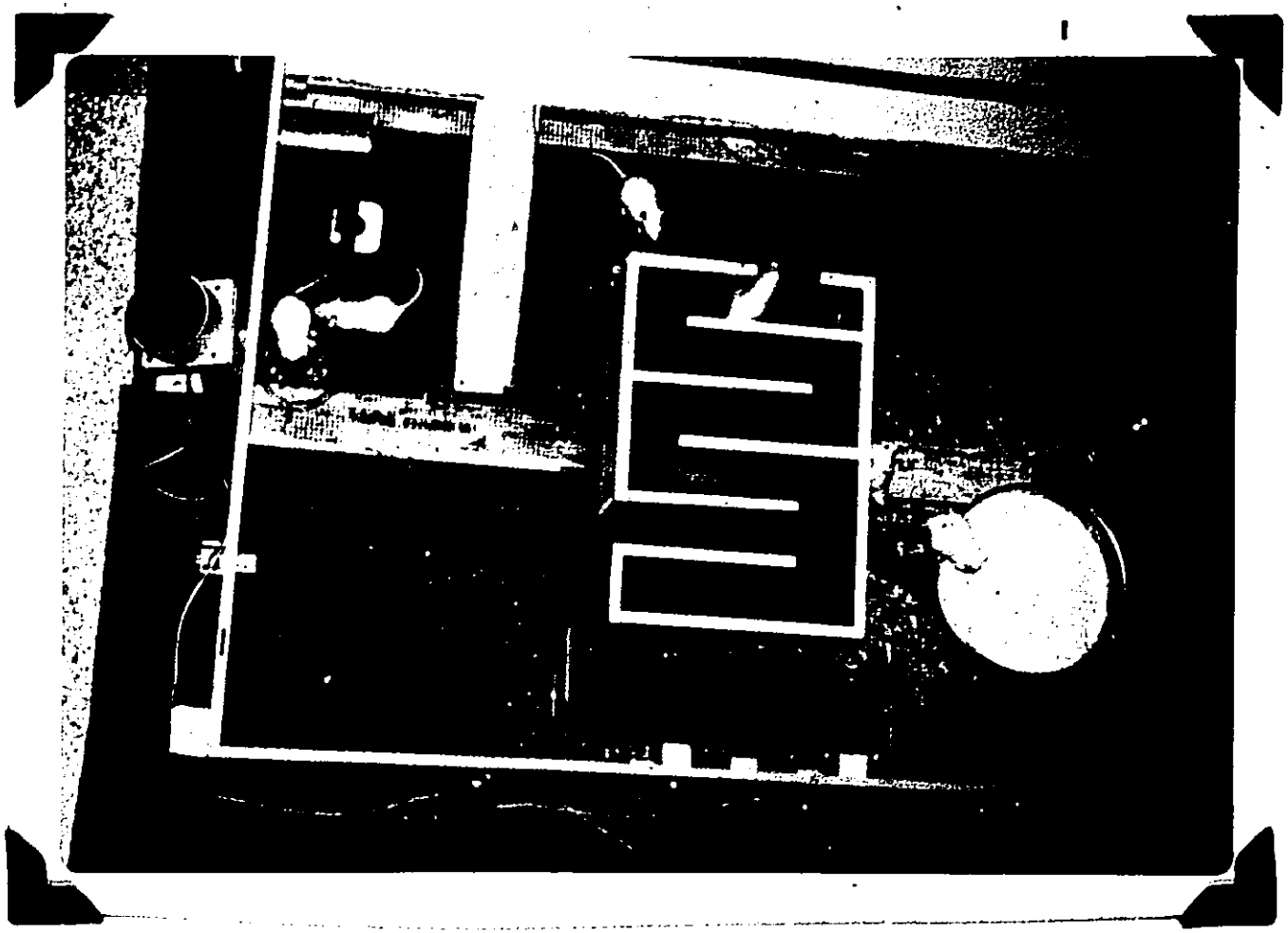

Photo 1. Enriched Response Independent Rearing Environment.

Testing Apparatus

A simultaneous two-choice discrimination box was used. The apparatus was constructed of 1.3 cm. thick plywood and divided into two basic areas; a V-shaped decision chamber and two goal chambers with walls 30 cm. high. Entry into the decision chamber was gained through a 18 X 10 X 8 cm. start box which had a hinged lid to prevent escape. A manually operated, clear plexiglass guillotine door could be lifted to expose the rat to the decision chamber. Dimensions of width and length of the various sections are shown in Figure 1. The animal, when in the decision chamber, was exposed to a double doorway discrimination panel. It had to push open a hinged, 10.5 X 10.5 cm. door to gain access into one of the two goal chambers. The entire apparatus was painted flat grey.

Interchangeable goal doors 0.5 cm. thick could be attached behind each doorway and could be locked from inside the goal chamber. During the pretraining phase, flat grey goal doors were used. During the testing phase, black horizontal and vertical rectangles (1.9 X 6 cm.) of mystic tape were attached to a flat white, painted background and used as stimulus goal doors. Each horizontal and vertical rectangle was positioned midway from each side and 1 cm. from the

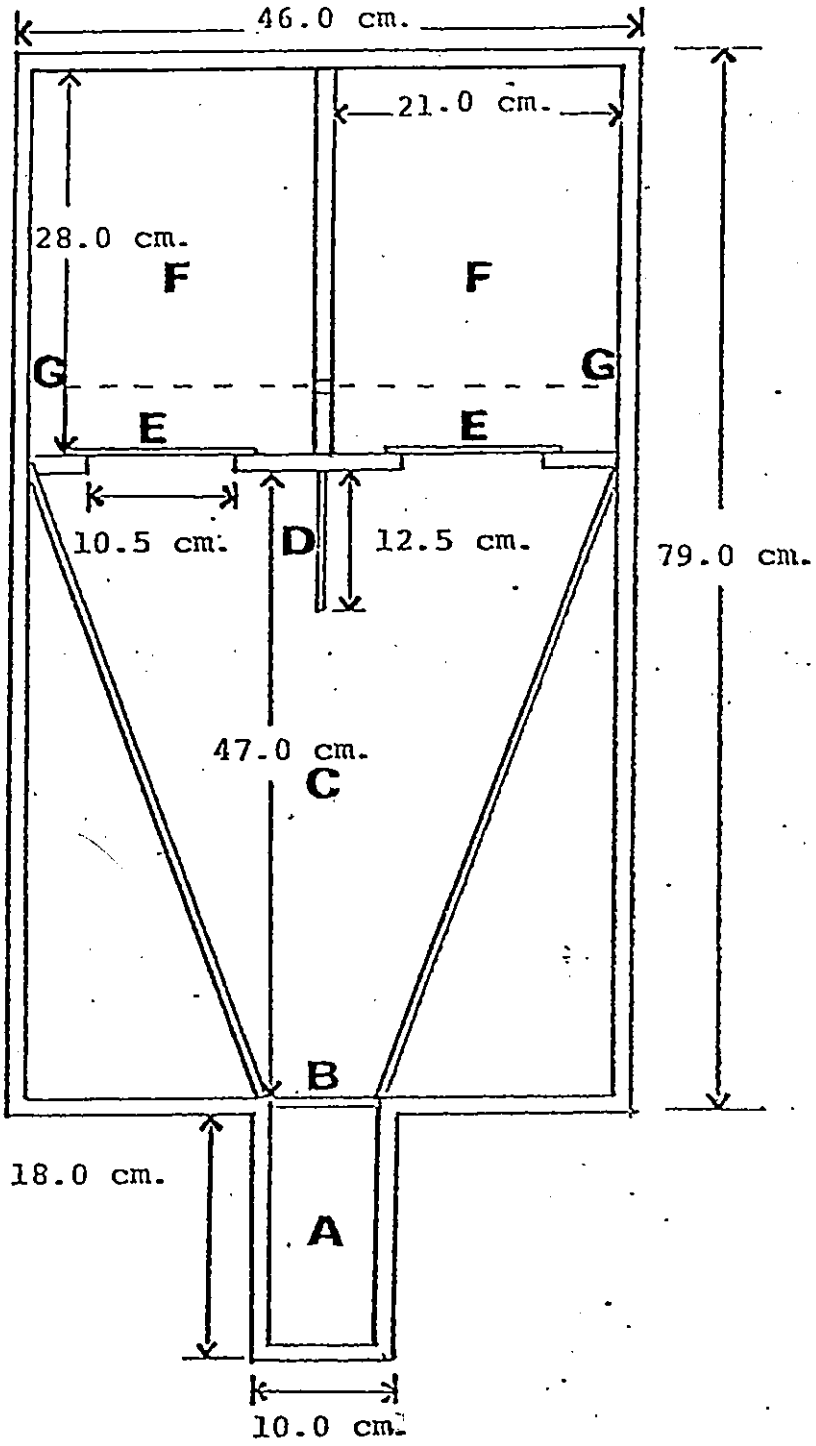

Figure 1 Floor Plan of Discrimination Box. After placement in the starting box (A) the guillotine door (B) is raised and the animal is allowed to enter the decision chamber (C). Opening of a goalbox door (E) breaks the photobeam (G) in the goal chamber (F). The approach areas to the goal chambers are seperated by a plexiglass divider (D).

lower edge of the goal door. The employment of these stimuli was expected to eliminate results found by Tees (1968) and Dodwell (1961) where rats trained to approach the vertical rectangle learned a discrimination task faster than those trained to approach the horizontal. In both previous studies, rectangles were centred, and since rats attend only to the lower one-third of the stimulus goal door, the vertical rectangle was a more salient cue. The only source of illumination used throughout the study was provided by a 25 watt incandescent lamp situated over the decision chamber above the start box opening.

A 10% sucrose solution (wt./vol.) was used as reinforcement. The bottles containing sucrose reinforcement were inserted through a hole in the rear wall of the goal chamber such that the drinking tube protruded approximately 6 cm. from the floor.

A microswitch above the guillotine start box door allowed for running speed to be recorded in the following manner. When the animal pressed it's nose against the start box door, the door was manually lifted, starting the clock (Standard Electric-Lafeyette-0.01 sec. accuracy). The clock ran until the rat pushed open a stimulus goal door which broke a photoelectric beam, stopping the clock. Therefore, time from

opening of the start box door by E to opening of goal door by S was denoted as the animal's running time and was recorded to the nearest 0.1 sec.

Procedure

Rearing. The experimental design employed 6 litters of 6 Ss, in replication, with one member of each litter being randomly assigned at 25 days of age to one of the rearing environments. Immediately before being introduced to rearing cages all Ss of each litter were weighed, then dyed with food colour for identification purposes during behavioral observation. Throughout preweaning Ss received minimal handling and upon being placed in rearing cages they experienced no further handling in their respective rearing environment 24 hr. a day for a 35 day period.

One member of each litter was assigned to the enriched response contingent group (ERC) and a second member to the impoverished response contingent group (IRC). Animals comprising RC groups had to bar press in order to receive food pellets and had the option of activating two other ceiling switches to turn on cue lamps (see Berlyne, 1969 for reward-value of light onset). Throughout the entire 35 day rearing period a CRF schedule was used. No shaping procedures were employed. Thus, RC

animals were responsible for maintaining their own diet. Two other members of each litter were assigned to enriched and impoverished response independent groups (ERI and IRI) where delivery of food pellets and light onset was controlled by Ss in the RC groups. For example, whenever a S in ERC pressed a lever and was reinforced with a food pellet, a second pellet was simultaneously delivered to the ERI cage, independent of any response that RI subjects made. RC rats controlled the occurence of food delivery and onset of light while RI Ss were deprived of this control. Thus, the two RI groups were yoked to their respective RC group. The remaining two members of each litter were assigned to enriched and impoverished control groups (EC and IC). These animals received the same number of food pellets as their corresponding RC and RI groups but these were delivered en masse in their pie plates at 11:00 a.m. daily. Cue lamps in C cages were never activated.

Throughout the rearing period Ss were observed 1-2 hours daily and observations recorded. Periods of observation varied from 8:00 a.m. to 12:00 midnight. Since no handling occurred during rearing, weights were not recorded and supplemental feedings to maintain a stable body weight could not be managed.

At the conclusion of the 35th day of rearing,

Ss were removed from colony cages, weighed, housed individually in a colony room, and placed on a 23.5 hr. water deprivation schedule. Upon assignment of Ss to individual cages, an experimenter double blind procedure was used to ensure that results were not attributable to biased experimenter expectancy,or the Rosenthal effect (Rosenthal and Fode, 1963). Animals were left undisturbed in their home cages for 1 day prior to commencement of pretraining to allow them to adapt to isolation housing and to a novel deprivation condition.

Pretraining. A 9 day pretraining procedure was used in order to habituate animals to the testing apparatus and train them to open the goal box door for reinforcement. This procedure was necessary not only for the forementioned reasons but recent research (Gardner et al., 1975) has indicated that perceptually enriched rearing produces greater exploratory behavior than socially enriched, but perceptually impoverished, rearing conditions. Rosenzweig et al., (1968) cite evidence which suggested that enriched rearing leads to habituation of exploratory behavior which may influence test results. The present procedure resolves these conflicting data by providing ample experience in the discrimination apparatus to reduce exploratory tendencies and permit distinction of acquisition

differences, without exploratory bias. During this phase Ss were maintained on a 23.5 hr. water deprivation schedule where they had 0.5 hr. access to water in their home cage immediately following each session. Throughout pretraining and testing phases Ss had ad lib access to Purina rat chow pellets in their home cage.

Days 1-3. Animals were handled for 5 min. to accustom them to the presence of and handling by E. Immediately following handling Ss were given 5 min. of free exploration of the discrimination box. No goal doors were present and animals were allowed to drink in the goal chambers where 10% sucrose solution was available. During this three day adaptation period fecal boli were counted as they have been found to be a standard measure of emotionality (eg. Archer, 1973; Denenberg, 1963; LaBarba and White, 1971; Levine, 1960; and Russell, 1971).

Days 4-9. Grey goal doors were introduced at this stage and Ss were trained in a series of graduated steps to leave the start box and push open the goal door to receive 10 sec. access to sucrose reinforcement. Animals were given 6 trials/day for the first four days and were allowed to enter either goal box for sucrose solution. On the following day there were again, 6 trials/day but an experimenter corrected procedure was

introduced in order to break position habits that may have been acquired. The animal was forced to choose the left (L) or right (R) position, determined randomly, according to Fellow's Sequence (1967). If the S approached and touched the locked door it was immediately removed from the decision chamber, returned to the start box and given another run. This procedure was continued for a maximum of 5 runs but on the fifth run, if the animal again made an error it was allowed to self-correct in order to prevent extinction. Subjects were reinforced only once on any trial. Day 9 of pretraining was identical to the previous day but 12, rather than 6, experimenter corrected trials were used. The 10 sec. access to reinforcement was used to prevent satiation from occurring before completion of pretraining trials.

During both pretraining and testing phases of the study, several standard procedures were used. Animals were run at the same hour each day. The technique used for all trials was to place the animal in the start box, wait until it touched the plexiglass retaining door with it's nose, then open the door allowing S entry to the decision chamber. Immediately upon leaving the start box the guillotine door was lowered preventing re-entry into the start box. Once in the decision chamber S was able to enter the goal chamber

only by approaching the unlocked door. After entry, the rat was allowed a 10 sec. drink of sucrose and was returned to it's home cage where it remained until all other Ss in it's group had completed their trials, then was removed and the procedure repeated. Animals were run in groups of 12; thus permitting an intertrial interval (ITI) of 6-7 min. between each of the 12 spaced trials. Odour trails were controlled by periodically wiping the floor with a damp cloth. Any spillage from the spout of the incentive bottle into the goal chamber was immediately cleaned.

Testing. Animals were 70 ($\pm$ 1) days old at the commencement of testing. The testing phase was designed to determine whether rearing animals in contingent or response independent conditions within enriched or impoverished environments would enhance discrimination learning in response contingent Ss and/or produce interference in response independent Ss. A simultaneous forced choice discrimination task was employed to determine whether learning performance differences exist due to differential rearing conditions. Animals received 12 experimenter corrected trials per day, each reinforced with a 10 sec. drink of 10% sucrose solution. A counterbalancing procedure was used such that half of each rearing group had a horizontal rectangle as S+

and vertical rectangle as S- and vice versa for the remaining Ss. Position of S+ was determined randomly over test trials according to Fellow's Sequence (1967). Acquisition criterion was two succesive sessions (24 trials) with a maximum of 2 errors.

The day following acquisition criterion, the positive and negative goal door cues were reversed. The previously nonreinforced goal door cue was now S+ and the previously reinforced cue was now S-. Reversal sessions were continued until a S reached the original acquisition criterion, then positive and negative stimulus goal door cues were again reversed. This procedure was continued (12 trials/day) for 30 days (360 trials). Running speed and errors were recorded for all Ss on all trials.

CHAPTER ~~III~~

RESULTS

Rearing

During the 35 day rearing period the number of responses produced on the two food delivery response levers and two light onset switches were recorded at 24 hr. intervals for ERC and IRC environments of both the first run and it's replication. Responding was subdivided into 5 day intervals and the mean number of daily responses over each of seven blocks is presented graphically in Figures 2 and 3. The data were not analysed statistically since recording from individual rats was not possible.

Figure 2 shows no appreciable differences in the number of responses for food pellets between ERC and IRC groups on any block or between runs 1 and 2. Daily bar pressing increased from slightly more than 1,500 on block 1, when Ss were 25-29 days old to approximately 4,000 when animals were 55-59 days of age on block 7.

Figure 3 indicates that differential responding for light onset existed but was primarily a function of run and not environmental rearing conditions. These differences are most clearly seen on blocks 4 and 5.

Throughout the period of differential rearing

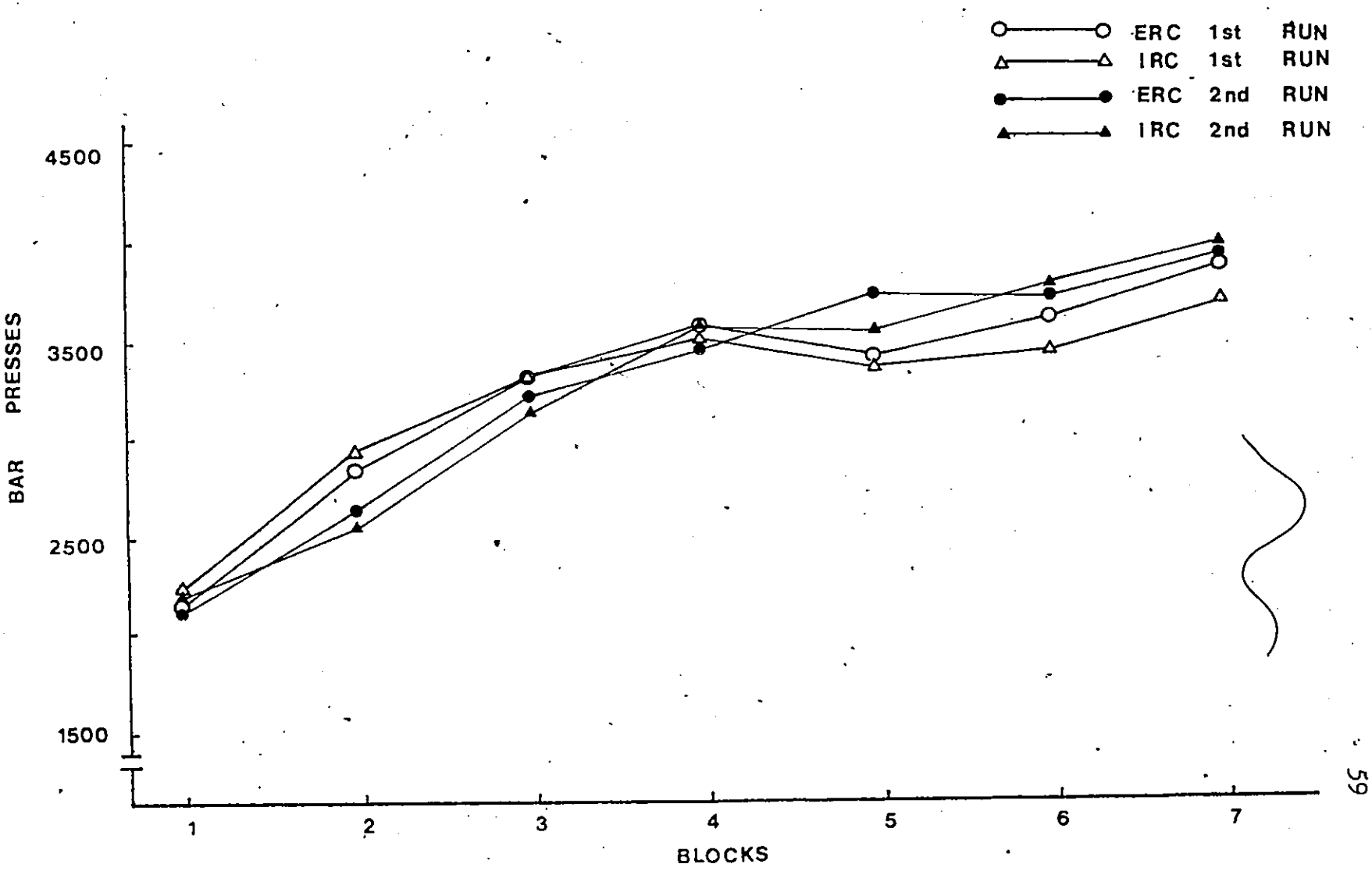

Figure 2. Mean No. of Daily Responses for Food Delivery over Blocks for ERC and IRC Groups of Runs 1 and 2.

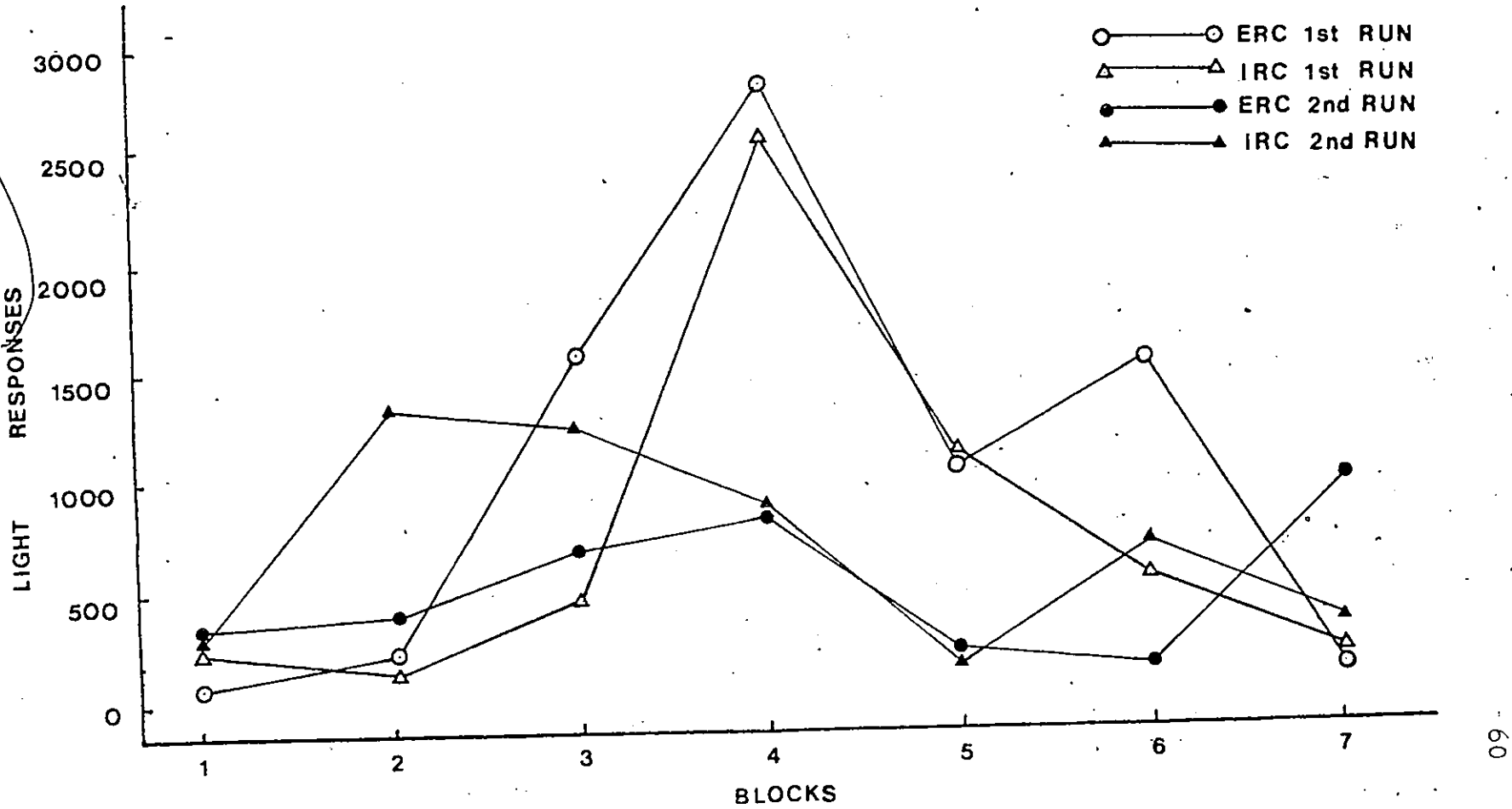

Figure 3. Mean No. of Daily Responses for Light Onset over Blocks for ERC and IRC Groups of Runs 1 and 2.

animals were observed 1-2 hr. daily and notes recorded. The notes taken during run 1 are presented in Appendix A. No systematic behavioral observations were recorded so Appendix A cannot be regarded as empirical data.

Emotionality

Data on emotionality were measured by the number of boli emitted by each S on each of the three daily, 5 min. free exploration periods. Both ERC and IRC animals of the first run emitted no boli throughout this period. These groups showed increased defecation in run 2. Table 1a, p. 62, presents total boli counts as a function of rearing conditions and run over the 3 day exploration period in the training apparatus. Similarily, Table 1b, p. 63, presents the number of animals emitting boli as a function of rearing conditions and run. These data indicated that RC Ss of the first run were less emotional than RI and C groups of both runs and their RC counterparts of the second run.

Since 38 of 72 animals over the two runs emitted no boli, Ss were categorized as those which emitted boli and those which did not. Chi square analyses showed that significantly more rats of the second run emitted boli during the free exploration period than did animals of the first run $[x^2(1) = 11.52, p < .01]$.

Table 1a

Total Fecal Boli Counts as a Function of Environmental and Contingent Rearing Conditions, and Run

Rearing Conditions		Run 1	Run 2
ENRICHED	RC	0	23
	RI	22	15
	C	17	14
IMPOVERISHED	RC	0	21
	RI	18	14
	C	9	23

Table 1b

Number of Animals Emitting Boli as a Function of Environmental and Contingent Rearing Conditions, and Run

Rearing Conditions		Run 1	Run 2
ENRICHED	RC	0	5
	RI	3	5
	C	3	4
IMPOVERISHED	RC	0	3
	RI	2	4
	C	2	3

The Run variable was subdivided into first and second run and analyzed for the effects of Environment and Contingency. Chi square analyses of contingent rearing conditions indicated that significantly fewer RC Ss of the first run emitted fecal boli than their RI or C counterparts $[x^2(2) = 6.93, p<.05]$. No differences existed between RI or C groups. No differences were found between any contingent rearing condition of the second run. Further analyses between runs found no differences between RI and C groups of the first or second run. However, significantly fewer RC Ss of the first run emitted boli than corresponding RC animals of the second run $[x^2(1) = 12.00, p<.01]$, as well as RI and C animals of the second run $[x^2(2) = 15.08, p<.01]$.

Chi square analyses revealed no emotionality differences between enriched or impoverished rearing conditions on either run. With Run collapsed there were no differences based on Contingency or Environment. Differences between runs were primarily a function of changes between RC groups.

Note should be made that during the rearing period of the second run a broken steam pipe in the colony room exposed all animals to aperiodic, intense noise. Since 5-6 days passed before the problem was rectified, the introduction of an uncontrolled variable

may have inadvertently influenced emotionality between runs. No such disturbance occurred during the first run. Casual observation indicated that upon removal from rearing environments rats of the first run were passive and easy to handle while those of the second squealed, defecated and ran around their cages seeking a safety zone.

To examine changes in emotionality over sessions ANOVA was undertaken. Animals were found to be most emotional on the first session of free exploration as measured by boli counts. The number of boli decreased from session 1 to session 2 but there was no further decrease from session 2 to 3. Mean boli per session as a function of environmental and contingent rearing conditions, and run are presented in Table 2a, p. 66, 67.

An Fmax test indicated that variance of emotionality data of the first run was heterogenous due to the total lack of variance in RC cells. Data was homogenous with runs collapsed. An Environment X Contingency X Session (repeated measure) ANOVA yielded identical results to ANOVA with runs included. Thus, an Environment X Contingency X Run X Session (repeated measure) ANOVA was carried out on boli data, even though the assumption of homogeneity was violated (Table 2b, p. 68). Due to the frequency of zero

Table 2a

Mean Boli per Session as a Function of Environmental and Contingent Rearing Conditions and Run (raw score, $\sqrt{x+.5}$ transformation, S.D. transformed score)

Rearing Conditions		n	RUN 1 SESSION 1	2	3
ENRICHED	RC	6	0, 0.70, 0.00	0, 0.70, 0.00	0, 0.70, 0.00
	RI	6	16, 1.48, 0.07	0, 0.70, 0.00	6, 1.01, 0.75
	C	6	10, 1.32, 0.72	7, 1.13, 0.67	0, 0.70, 0.00
IMPOVERISHED	RC	6	0, 0.70, 0.00	0, 0.70, 0.00	0, 0.70, 0.00
	RI	6	11, 1.26, 0.93	7, 1.13, 0.67	0, 0.70, 0.00
	C	6	3, 0.90, 0.48	1, 0.79, 0.21	5, 0.97, 0.67

Table 2a (con't)

Mean Boli per Session as a Function of Environmental and Contingent Rearing Conditions and Run (raw score, $\sqrt{x+.5}$ transformation, S.D. transformed score)

Rearing Conditions		n	RUN 2 SESSION 1	2	3
ENRICHED	RC	6	14, 1.60, 0.56	5, 0.97, 0.67	4, 0.94, 0.58
	RI	6	9, 1.23, 0.60	6, 0.01, 0.75	0, 0.70, 0.00
	C	6	12, 1.46, 0.67	2, 0.85, 0.36	0, 0.70, 0.00
IMPOVERISHED	RC	6	14, 1.48, 0.87	6, 1.13, 0.51	1, 0.79, 0.21
	RI	6	9, 1.32, 0.54	3, 0.93, 0.38	2, 0.85, 0.36
	C	6	7, 1.13, 0.67	7, 1.19, 0.55	9, 1.21, 0.79

Table 2b

Environment X Contingency X Run X Session (repeated measure) ANOVA for Emotionality Data

Source of Variation	SS	df	MS	F
Between Ss	33.596	71		
A (Environment)	0.008	1	0.008	0.02
B (Contingency)	0.713	2	0.357	0.72
C (Run)	1.461	1	1.461	3.03
AB	0.002	2	0.001	0.00
AC	0.324	1	0.324	0.42
BC	1.883	2	0.942	1.95
ABC	0.236	2	0.118	0.24
Ss within groups	28.969	60	0.483	
Within Ss	32.777	144		
D (Sessions)	6.196	2	3.098	17.73**
AD	0.872	2	0.436	2.50
BD	0.326	4	0.082	0.47
CD	0.732	2	0.366	2.10
ABD	1.194	4	0.299	1.71
ACD	0.074	2	0.037	0.21
BCD	1.340	4	0.335	1.92
ABCD	1.073	4	0.268	1.54
D X Ss within groups	20.970	120	0.175	

** $p < .0001$

scores, raw data was normalized using $\sqrt{x+.5}$ transformation (Winer, 1971). A significant main effect was found for Sessions [$F(2,120) = 17.73$, $p < .0001$]. No significant interactions were found.

To further investigate the main effect for Session, individual comparisons (Newman-Keuls procedure) were employed and are presented in Table 2c, p. 70. Comparisons indicate that rats emitted more boli on session 1 than on sessions 2 and 3 ($p < .01$), but there was no significant decrease from session 2 to 3.

In summary, analyses of emotionality data indicated that:

1) More animals of the second run emitted boli during the free exploration period than those of the first. Fewer RC Ss of the first run dropped boli than RI and C animals of the same run and RC, RI, and C Ss of the second run. No differences in emotionality were found between RI and C groups either between or within runs.

2) Neither chi square nor ANOVA indicated any difference based upon enriched or impoverished rearing conditions.

3) Animals were most emotional on the first session of exposure to a novel situation. By the

Table 2c

Individual Comparisons (Newman-Keuls Procedure)

for Emotionality Data

Comparisons Between Days

Critical Difference

r		2	3
.05	=	0.14	0.17
.01	=	0.19	0.21

DAY	2	1
3	0.13	0.41**
2		0.28**
1		

** $p < .01$

second session emotionality had decreased substantially and no further decrease occurred on the third session.

Acquisition Criterion

Three dependent measures (Sessions, Errors, and Persistent Errors) were assessed during the acquisition phase of the study. Data are presented accordingly.

The number of daily sessions to criterion was recorded as the day when a S attained the arbitrarily defined criterion of two succesive sessions with a maximum of two errors. However, if S had not achieved criterion within 20 sessions the acquisition phase was terminated and reversal training commenced the following day. If S was within range of criterion attainment on session 20 (i.e. made 2 or less errors) 1 session was added to it's score so that it was assigned a total of 21 sessions. If S was not within range (i.e. made 3 or more errors) 2 sessions were added to it's total score.

Rats reared in perceptually enriched environments were found to reach acquisition criterion in fewer sessions ($\bar{X}$=10.97) than those reared in conditions of impoverishment ($\bar{X}$=12.64). In addition it was observed that animals trained with the horizontal rectangle as the positive stimulus learned the discrimination in

fewer sessions ($\bar{X}$=9.19) than those trained with the vertical rectangle ($\bar{X}$=14.42). Response contingent and independent rearing had no influence on the number of sessions to criterion. Table 3a, p. 73, presents the mean number of sessions to acquisition as a function of Rearing conditions, Discrimination Task, and Run.

An Environment X Contingency X Task X Run ANOVA was carried out on sessions to criterion data (Table 3b, p. 74). Significant main effects were found for Environment [$F(1,48) = 5.52$, $p < .02$] and Task [$F(1,48) = 54.21$, $p < .0001$]. No significant interactions were found.

Errors to criterion were recorded as the total number of errors made up to and including the session of acquisition. For Ss which were not able to reach criterion by session 20, no further errors were added to their total score. The mean number of errors to criterion as a function of Rearing Environment, Discrimination Task, and Run are presented in Table 4a, p. 75. Results compliment the Sessions to criterion data indicating that enriched reared rats learned the discrimination task making fewer errors ($\bar{X}$=67.56) than those reared under conditions of impoverishment ($\bar{X}$=79.36). Similarily, Ss trained with a horizontal rectangle as S^D made fewer errors to acquisition ($\bar{X}$=55.61) than animals trained to approach a vertical rectangle ($\bar{X}$=91.31).

Table 3a

Mean Number of Sessions to Criterion as a Function of Environmental and Contingent Rearing Conditions, Discrimination Task and Run

Rearing Condition		Run 1		Run 2	
		HORIZ.	VERT.	HORIZ.	VERT.
ENRICHED	RC	8.33	12.00	9.33	12.67
	RI	6.33	11.00	10.00	13.67
	C	8.67	15.67	9.00	15.00
IMPOVERISHED	RC	8.67	12.33	10.00	17.33
	RI	9.67	17.33	11.00	13.67
	C	8.67	15.33	10.67	17.00

Table 3b

Environment X Contingency X Discrimination Task X Run

ANOVA for Sessions to Criterion

Source of Variation	SS	df	MS	F
A (Environment)	50.00	1	50.00	5.52*
B (Contingency)	18.11	2	9.06	1.00
C (Task - HV)	490.89	1	490.89	54.21**
D (Run)	29.39	1	29.39	3.25
AB	10.33	2	5.17	0.57
AC	4.50	1	4.50	0.50
BC	14.87	2	7.39	0.82
AD	0.00	1	0.00	0.00
BD	4.87	2	2.39	0.26
CD	2.00	1	2.00	0.22
ABC	3.00	2	1.50	0.17
ABD	42.33	2	21.17	2.34
ACD	0.06	1	0.06	0.01
BCD	16.33	2	8.18	0.90
ABCD	12.11	2	6.06	0.67
Within Cell Error	434.67	48	9.06	
Total	1133.28	71		

* $p < .02$

** $p < .0001$

Table 4a

Mean Number of Errors to Criterion as a Function of Environmental and Contingent Rearing Conditions, Discrimination Task and Run

Rearing Condition		Run 1		Run 2	
		HORIZ.	VERT.	HORIZ.	VERT.
ENRICHED	RC	47.67	80.67	55.00	72.00
	RI	40.33	67.67	60.33	79.33
	C	58.33	116.33	49.67	83.33
IMPOVERISHED	RC	65.67	92.67	62.00	114.33
	RI	61.00	112.67	55.33	78.67
	C	52.33	101.00	59.67	97.00

An Environment X Contingency X Discrimination Task X Run ANOVA examined the total number of errors to criterion (Table 4b, p. 77). Significant main effects were found for Environment [$F(1,48) = 5.88$, $p < .02$] and Task [$F(1,48) = 53.79$, $p < .0001$]. A significant interaction was found for Environment X Contingency X Run [$F(2,48) = 3.29$, $p < .05$].

To further investigate the interaction, a series of individual comparisons (Newman-Keuls procedure) were undertaken and are presented in Table 4c, p. 78, and Table 4d, p. 79. From these individual comparisons it was found that ERI Ss of the first run made significantly fewer errors than IRI animals ($p < .01$) of the same run. ERC animals made significantly fewer errors than IRC animals ($p < .05$) during run 2.

Comparisons between contingencies for each rearing condition indicated that during the first run ERI Ss made significantly fewer errors ($p < .05$) than EC Ss to criterion. No differences were found between contingency levels for impoverished animals of the first run or enriched and impoverished animals of the second run.

Comparisons between runs for each contingency group within each environmental rearing condition revealed no significant differences.

Persistent errors were defined as the total

Table 4b

Environment X Contingency X Discrimination Task X Run

ANOVA for Errors to Criterion

Source of Variation	SS	df	MS	F
A (Environment)	2508.68	1	2508.68	5.88**
B (Contingency)	731.58	2	365.79	0.86
C (Task - HV)	22933.68	1	22933.68	53.79***
D (Run)	110.01	1	110.01	0.26
AB	1203.53	2	601.77	1.41
AC	342.35	1	342.35	0.80
BC	696.69	2	348.35	0.82
AD	6.13	1	6.13	0.01
BD	569.19	2	248.60	0.67
CD	496.13	1	496.13	1.16
ABC	300.53	2	150.27	0.35
ABD	2801.58	2	1400.79	3.29*
ACD	147.35	1	147.35	0.35
BCD	517.75	2	258.88	0.61
ABCD	706.69	2	353.35	0.83
Within Cell Error	20464.00	48	426.33	
Total	54535.88	71		

* $p < .05$

** $p < .02$

*** $p < .0001$

Table 4c

Individual Comparisons (Newman-Keuls Procedure)

for Mean Errors to Criterion

Comparisons between Rearing Environment for each Run within each Contingency Level

Critical Difference

.05 = 24.03

.01 = 31.95

	Enriched vs. Impoverished		
	RC	RI	C
Run 1	N.S.	I>E**	N.S.
Run 2	I>E*	N.S.	N.S.

* $p < .05$

** $p < .01$

Table 4d

Individual Comparisons (Newman-Keuls Procedure)

for Mean Errors to Criterion

Comparisons between Contingency Levels for each Rearing Environment within each Run

Critical Difference	2	3
.05 =	24.03	28.83
.01 =	31.95	36.50

	ENRICHED			IMPOVERISHED	
RUN 1	RC	C		RC	RI
	RI 10.17	33.33*	C	2.50	10.16
	RC	23.16	RC		7.66
	C		RI		
RUN 2	C	RI		C	RC
	RC 3.00	6.33	RI	11.33	21.17
	C	3.33	C		9.84
	RI		RC		

* $p < .05$

number of errors made on any given trial (max. = 5), less the first error made. Thus, Ss could possibly make 4 persistent errors per trial. Table 5a, p. 81, presents the mean number of Persistent Errors to criterion as a function of Rearing Environment, Discrimination Task, and Run. Animals of the second run attained acquisition criterion with fewer persistent errors ($\bar{X}$=15.17) than those of the first run ($\bar{X}$=23.25). In addition, IRC Ss were observed to make more persistent errors than their ERC counterparts.

An Environment X Contingency X Discrimination Task X Run ANOVA examined the total number of persistent errors to initial acquisition (Table 5b, p. 82). A significant main effect was found for Run [$F(1,48) = 12.82$, $p < .001$]. A significant interaction was found for Environment X Contingency [$F(2,48) = 3.12$, $p < .05$].

Individual comparisons (Duncan's method) showed that rats of the second run reached acquisition making significantly fewer ($p < .01$) persistent errors than animals of the first run. Further comparisons (Newman-Keuls procedure) between rearing Environments within each Contingency Group indicated that IRC Ss made significantly more persistent errors to criterion than ERC Ss ($p < .05$). No differences were found within RI or C groups (Table 5c, p. 83). Comparisons between Contingency groups within

Table 5a

Mean Persistent Errors to Criterion as a Function of Environmental and Contingent Rearing Conditions, Discrimination Task and Run

Rearing Conditions		Run 1		Run 2	
		HORIZ.	VERT.	HORIZ.	VERT.
ENRICHED	RC	17.67	23.33	14.67	6.00
	RI	17.33	20.33	18.00	14.33
	C	23.67	38.33	11.33	14.67
IMPOVERISHED	RC	27.67	33.33	17.33	21.00
	RI	17.33	23.00	15.33	14.67
	C	14.67	11.00	22.33	23.67

Table 5b

Environment X Contingency X Discrimination Task X Run

ANOVA for Persistent Errors to Criterion

Source of Variation	SS	df	MS	F
A (Environment)	58.68	1	58.68	0.64
B (Contingency)	100.33	2	50.17	0.55
C (Task - HV)	300.13	1	300.13	3.27
D (Run)	1176.13	1	1176.13	12.82**
AB	573.44	2	286.72	3.12*
AC	51.68	1	51.68	0.56
BC	273.00	2	136.50	1.49
AD	160.33	2	80.17	0.87
BD	86.68	1	86.68	0.94
CD	159.01	1	159.01	1.73
ABC	19.44	2	9.72	0.11
ABD	349.77	2	174.89	1.91
ACD	105.13	1	105.13	1.15
BCD	19.44	2	9.72	0.11
ABCD	52.00	2	26.00	0.28
Within Cell Error	4404.67	78	151.53	
Total	7889.88	71		

* $p \leq .05$

** $p < .001$

Table 5c

Individual Comparisons (Newman-Keuls Procedure)

for Total Persistent Errors to Criterion

Comparisons between Environments within each Contingency Group		
Critical Difference		
.05 = 7.87		
.01 = 10.46		
RC	RI	C
9.41 *	0.08	4.08
(I > E)		

* $\tilde{p} < .05$

each rearing Environment revealed no significant differences.

In summary, analyses of acquisition data indicated that:

1) Enriched reared rats learned a horizontal-vertical rectangle discrimination task in fewer sessions and with fewer errors than their impoverished reared counterparts.

2) Animals trained to criterion with the horizontal rectangle as S^D learned the task faster and with fewer errors than those trained with a vertical rectangle as S^D.

3) During the first run ERI Ss made fewer errors than IRI or EC rats of the same run, while ERC animals of the second run made fewer errors than their IRC counterparts.

4) Animals of the second run made fewer persistent errors to criterion than those of the first run. Enriched reared RC animals made fewer persistent errors to criterion than IRC Ss.

(See Table 6, p. 85, for an overall summary of mean scores to criterion).

Reversal Training

The total number of reversals attained and the total number of errors made during the 30 sessions

Table 6

Mean Scores to Criterion as a Function of Environment, Contingency, Discrimination Task and Run

		SESSIONS	ERRORS	PERSISTENT ERRORS	n
Environment	ENR.	10.97	67.56	18.31	36
	IMP.	12.64	79.36	20.11	36
Contingency	RC	11.33	73.75	20.13	24
	RI	11.58	69.42	17.54	24
	C	12.50	77.21	19.96	24
Discrimination Task	H	9.19	55.61	17.17	36
	V	14.42	91.31	21.25	36
Run	1	11.17	74.69	23.25	36
	2	12.44	72.22	15.17	36

of succesive reversal training were analyzed.

Of the 72 Ss used in the study only 3 were able to make more than one succesful reversal; respectively 5, 5, and 6. No animal made 2, 3, or 4 reversals. Approximately half of the Ss were unable to complete a reversal in the alotted period although there were no consistencies regarding their group of origin. An Environment X Contingency X Discrimination Task X Run ANOVA analysed the number of reversals performed and found no significant main effects or interactions.

The total number of errors made during the 30 session reversal period, regardless of whether or not a reversal was attained, were also analysed. The means of total errors during reversal training as a function of Rearing Conditions, Discrimination Task, and Run are presented in Table 7a, p. 87. The IRI animals of the first run were observed to make fewer total errors than IRI Ss of run 2 or ERI Ss of run 1. No other differences were found.

An Environment X Contingency X Discrimination Task X Run ANOVA was carried out on the total number of errors made during reversal training (Table 7b, p. 88). No significant main effects were found. A significant interaction was found for Environment X Contingency X Run [$F(2,48) = 3.64$, $p < .04$].

Table 7a

Mean Total Errors during Succesive Reversal Training as a Function of Environmental and Contingent Rearing Conditions, Discrimination Task and Run

Rearing Conditions		Run 1		Run 2	
		HORIZ.	VERT.	HORIZ.	VERT.
ENRICHED	RC	213.00	221.33	231.00	224.67
	RI	242.33	215.33	216.33	211.33
	C	196.33	224.67	224.00	223.33
IMPOVERISHED	RC	205.67	224.33	103.00	212.00
	RI	186.33	192.33	231.67	221.67
	C	224.67	216.00	204.33	221.33

Table 7b
Environment X Contingency X Discrimination Task X Run
ANOVA for Total Errors During Succesive
Reversal

Source of Variation	SS	df	MS	F
A (Environment)	1521.68	1	1521.68	2.01
B (Contingency)	56.58	2	28.29	0.04
C (T_{ask} - HV)	196.68	1	196.68	0.26
D (Run)	342.35	1	342.35	0.45
AB	680.86	2	340.43	0.45
AC	245.68	1	245.68	0.32
BC	1365.36	2	682.68	0.90
AD	36.13	1	36.13	0.05
BD	459.03	2	229.52	0.30
CD	17.01	1	17.01	0.02
ABC	665.53	2	332.77	0.44
ABD	5517.75	2	2758.88	3.64*
ACD	125.35	1	125.35	0.17
BCD	77.69	2	38.85	0.05
ABCD	1621.19	2	810.60	1.07
Within Cell Error	36400.00	48	562.13	
Total	49328.88	71		

* $p < .04$

To further examine the interaction effect a series of individual comparisons (Newman-Keuls procedure) was undertaken. Comparisons between Environmental rearing conditions within Contingencies indicated that on run 1 ERI Ss made significantly more errors during the 30 session reversal period than IRI Ss ($p < .05$). No other differences were observed within contingency levels on the first or second run (Table 7c, p. 90).

Comparisons between Runs for each Environmental rearing condition within each Contingency level showed that IRI Ss of run 1 made significantly fewer errors ($p < .05$) than their IRI counterparts of run 2 (Table 7d, p. 91). No other significant differences were found.

Comparisons between Contingency levels within each Environmental rearing condition and Run revealed no differences.

In summary, analyses of data during the 30 sessions of succesive reversal training indicated that:

1) No group differed from any other as to the number of reversals attained.

2) Impoverished RI animals of the first run made fewer errors during the reversal period than IRI Ss of run 2 or ERI Ss of the first run.

Table 7c

Individual Comparisons (Newman-Keuls Procedure) for Total Errors During Succesive Reversal Training

Comparisons between Rearing Environments for each Run within each Contingency Level

Critical Difference

.05 = 32.03

.01 = 42.60

	Enriched vs. Impoverished		
	RC	RI	C
Run 1	N.S.	E>I*	N.S.
Run 2	N.S.	N.S.	N.S.

* $p < .05$

Table 7d

Individual Comparisons (Newman-Keuls Procedure) for Total Errors During Succesive Reversal Training

Comparisons Between Runs for each Rearing Condition within each Contingency Group

Critical Difference

.05 = 32.03

.01 = 42.60

	Enriched	Impoverished
RC	N.S.	N.S.
RI	N.S.	Run 2 > Run 1 (37.34)*
C	N.S.	N.S.

* $p < .05$

CHAPTER IV

DISCUSSION

Rearing

Results of the rearing phase appear to show no appreciable differences between ERC and IRC groups. The most important measure recorded during this period was the number of daily responses for food pellets which indicated no differences on any block either between or within runs. On block 1 when Ss were 25-29 days of age the mean number of bar presses/S was roughly 250. Responding gradually increased for all RC groups so that on block 7 when rats were 55-59 days old the mean number of food responses/S was slightly more than 600 daily. Although there was some spillage in RC groups, it was minimal and could not be considered a salient determinant of the high response rate.

The results of the rearing phase of the present study are discrepant to those reported by Wheatley, Welker, and Miles (1977) who found that at 60 days of age the mean number of pellets consumed daily was approximately 200/rat in comparison to approximately 600 in this research. The major differences between the two studies were cage size, social conditions, and schedule of reinforcement. Wheatley et al. (1977) housed Ss individually from d. 45-60 in a small (25 X 25 X 30 cm.)

cage whereas Ss in this study were reared 6/cage in a large free environment. It is quite possible that differences in activity level alone due to differential social conditions may have accounted for discrepant feeding behavior. In addition, the former study employed an FR 25 food cup contacting response from d. 3-15 of pretraining whereas the present study used a CRF bar pressing schedule throughout.

Unfortunately the number of bar presses in RI and C cages was not recorded but the elevated response rate of RC Ss indicates that the CRF schedule was effectively controlling their bar pressing behavior. Thus, the 35 d. rearing period permitted adequate time for the acquisition of a contiguous relationship between an operant response and it's outcome on the part of RC animals. However, the effect of RI rearing must remain somewhat ambiguous at least as related to noncontingent food delivery.

Although there was periodically a surplus of pellets in RI cages, these animals would usually have to compete for food and would often lie in waiting near, and frequently in the food dish for the delivery of food. Response independent animals did not learn a contingent relationship between voluntary responding and food delivery to the same extent as did RC Ss,

but they may have developed some degree of instrumental control over feeding behavior through response competition with cagemates. Dominance hierarchies may have developed so that the dominant rat would have controlled access to the food dish while animals of lower dominance would have to wait their turn, in effect making their responding even less dependent. However, this must remain speculative as individual observations were not systematically recorded.

Responding for light onset indicated differences on several blocks which were a function of run rather than rearing conditions. It is interesting to note that on blocks 4 and 5 animals of both ERC and IRC groups of run 1 responded at higher levels than their counterparts of run 2. No differences were apparent between environmental rearing conditions of either run. Since most light onset responding occurred during the 12 hr. dark cycle and since all colony cages were housed in the same room, light onset in one RC cage may have provided very dim illumination which may have elicited responding by Ss in the other RC cage thus explaining observed differences between runs.

It was unlikely that differential responding for light on a given block would result in dissimilar degrees of competence in RC groups as the overall

number of responses for light was relatively stable. Response contingent animals of the present study were definitely able to acquire response-outcome contiguity regarding light onset. However, it can be stated unequivically that RI Ss experienced no contiguity or effective control over onset or termination. On several occasions the onset of light was actually observed to elicit a startle response in those RI rats in close proximity to the source of stimulation.

Emotionality

The prediction that RC rearing would reduce emotionality in relation to RI rearing was partially validated by the results. However, the prediction that enriched reared animals would be less emotional than those reared in impoverishment was not substantiated either by a chi square analyses or ANOVA procedures.

An examination of the Run variable showed that roughly 50% of Ss over the two runs emitted no boli. Further analyses revealed that more Ss of run 2 dropped boli than those of the first run. Since animals were reared under virtually identical conditions these results were unexpected and considered to be either an artifact or due to the occurrence of an uncontrolled and interfering variable. The only

dissimilarity between runs that E was aware of was the appearance of unpredictable and uncontrollable noise during the rearing phase of the second run.

Contingency analyses of the Run variable indicated that fewer RC Ss of run 1 emitted boli than RI and C animals of that run, or than RC, RI and C animals of the second run. No differences existed between RI and C groups of the first run or between any group of the second run. Also, no differences were found between RI and C groups between runs. Therefore, the difference in the number of Ss emitting boli between runs 1 and 2 were fundamentally due to the RC Ss of run 1.

Results of the first run support the findings of Joffe et al., (1973). Animals reared in RC environments, where delivery of food and light onset was contingent upon an instrumental response, were found to be less emotional as measured by defecation in a novel environment. Joffe et al., (1973) did not employ a C group in their study but suggested that the amount of operant control experienced by their RI Ss was comparable to that experienced by rats in a normal laboratory setting. The present results appear to support their hypothesis as RI and C animals of both runs did not differ in emotionality. The findings

of the first run indicated that it was not RI rearing which increased emotionality but that early experience with controllability decreased it. Generalizing from the results of the first run and from Joffe et al.(1973), it appears that early control over environmental events or the establishment of a sense of competence is another variable that affects emotionality.

Results of the second run were discrepant from those of the first and revealed that no differences existed between groups reared under different contingency conditions. Since no differences in emotionality were observed in RI or C groups between runs, possible explanations for discrepancies between RC groups must be inferred.

If RI rearing does not increase emotionality, as it does not seem to since these animals did not differ from C Ss, and if RC reduces it, then some discrepancy must have occurred between runs and affected RC animals only. Why were RC Ss of the second run more emotional than their first run counterparts? Glass and Singer (1972) examined noise as a stressor on human behavior and found that it resulted in a behavioral residue which had adverse effects on subsequent behavior (i.e. performance was impaired, frustration tolerance lowered, and inability to resolve cognitive conflict

heightened). They suggested that prolonged exposure to unpredictable and inescapable noise could result in augmented emotionality in humans.

Archer (1973) suggested that defecation as an index of emotionality in rats was directly related to high levels of stimulus intensity such as noise and light.

Inescapable and unpredictable noise places the organism in a situation where controllability is removed, where it has no influence over the removal of the stressor, and is unable to anticipate it's occurrence. Such conditions are in accordance with those employed to induce a state of learned helplessness. If Ss had control or even perceived control over the stressor, then behavioral aftereffects of exposure to noise were minimized.

Seligman (1975) presented evidence to support this interpretation. When S was initially presented with a stressor it elicited a heightened state of emotionality which he called fear. If the organism learned that it's responding was efficacious in controlling the stressor, the concomitant state of fear was reduced and might eventually extinguish. However, if S ultimately learned or perceived the situation as uncontrollable, fear would be replaced with a less specific state of anxiety which is chronic and not bound to any distinct

object. Support for this hypothesis was provided by Denny and Ratner (1970) who implied that early traumatic experience leading to a fear reaction may generalize very broadly and result in permanent emotional differences when compared to animals not so exposed.

Conditions during the rearing period of the second run were quite similar to those mentioned above. All groups were exposed to intense noise that was both aperiodic and uncontrollable for a 3-6 day period. Both RC cages were in close spatial proximity to the source but ERC and ERI cages were closest. Thus, the inadvertent appearance of a stressor may have been the influential factor that augmented emotionality levels in RC groups between runs. Response contingent animals were effectively controlling aspects of their immediate environment when this was unintentionally interrupted by a noxious stimulus which may have been present for sufficient duration to mediate emotional changes in these Ss. However, no systematic attempt was undertaken to examine this hypothesis so it must remain speculative.

If the unintentional introduction of noise did increase the emotional response of RC animals to a level consistent with RI and C groups, would a corresponding increase not be expected in these groups as well, or would the aperiodicity and uncontrollability have a

more profound influence on RC Ss? Given that RC rearing reduces emotionality rather than RI rearing increasing it, a credible hypothesis is that uncontrollable events would have a greater influence on animals which were effectively exerting control over their environment, placing them in circumstances similar to Ss already experiencing noncontingent reinforcers. Until a controlled study is undertaken to examine this hypothesis, the emotionality results of the present study must by considered somewhat ambiguous and subject to different interpretations.

Although the prediction that RC rearing would reduce emotionality was partially confirmed, no evidence was found to support the prediction that enriched rearing would result in decreased emotionality in relation to impoverished rearing. No emotionality differences based upon perceptual rearing environments existed either in the first or second run. These findings do not support those of Denenberg and Morton (1962), Forgus (1954), or Woods et al. (1960) who found rats reared in restricted environments to be more emotional. They do support Smith (1972) who found no emotionality differences resulting from enriched or restricted postweaning environments.

Emotionality differences as a function of free enriched or restricted rearing environments have

been, at best, ambiguous and inconsistent. In much of this research enriched reared animals were reared in groups ranging from 4-24 Ss. Restricted animals were typically reared in isolation or with one cagemate in a standard laboratory cage. Therefore both cage size and social rearing differences may have contributed to emotionality differences which were often solely attributed to environmental rearing conditions. Results of the present experiment suggest that with cage size and population density held constant emotionality is not a function of the perceptual environment.

One finding consistent to all groups was that emotionality was found to wane with repeated exposure to a novel environment. Animals eliminated more boli on session 1 than on sessions 2 and 3 and less during session 3 than session 2. But the difference between session 2 and 3 was not statistically significant. These findings support those cited by Archer (1973), that emotionality decreases as Ss habituate to a novel situation.

Acquisition Training

The prediction that perceptual enrichment during rearing would facilitate subsequent discrimination learning was confirmed. Enriched reared rats attained

acquisition criterion in fewer sessions and with fewer errors than their perceptually impoverished counterparts. These findings are consistent with earlier research examining the effects of differential rearing environments on problem-solving behavior (i.e. Forgays and Forgays, 1952; Forgays and Read, 1962; Forgus, 1954; and Hymovitch, 1952) and more recent work in this area (i.e. Denenberg, Woodcock, and Rosenberg, 1968; Greenough, Madden, and Fleischmann, 1972; Ivinskis and Ivinskis, 1976; and Smith, 1972).

The prediction that RI rearing would result in animals acquiring the discrimination task slower and with more errors than rats reared in RC environments was not confirmed. Observed differences between groups raised in differential contingent environments were seen as being more a function of perceptual rearing than of contingent conditions. Results of the present research do not support prior studies where response independent rearing in an appetitive situation was found to interfere with subsequent learning-performance in a different and controllable situation (Wheatley, Welker, and Miles, 1976; and Wight and Katzev, 1977).

What is it about enriched experience early in life that results in enhanced problem-solving and perceptual abilities? Most research in this field has indicated

that early enriched exposure facilitates subsequent performance. This effect was found not only in test situations where Hebb-Williams maze learning was the dependent measure (Forgays and Read, 1962) but also in a Lashley III maze (Greenough, 1975) and in a perceptual discrimination task in the present study. The effect was found when animals were tested immediately or shortly after being removed from rearing environments (Hymovitch, 1952) and after considerable time had elapsed (Forgays and Read, 1962; Denenberg et al., 1968).

What these and other findings suggest is consonant with Hebb's (1949) theory that enriched perceptual experience at an early age leads to neurological changes which will enhance problem-solving performance and make Ss better able to profit from new experiences. Hebb suggested that early perceptual experience would serve to organize perceptual behavior which would, in turn, generalize and affect later perceptual performance. Animals reared in isolation and deprived perceptual environments would not have developed the same elevated level of perceptual organization and subsequently exhibit poorer learning ability on perceptual tasks. Results of the present study suggest that differences due to perceptual rearing

conditions were of degree. All but four impoverished animals were able to learn the discrimination task within 20 sessions which suggests that they would eventually master the problem regardless of prior perceptual experience.

The present study controlled for social density and cage size, two very important variables that had been overlooked in much of the prior research. In many cases rats were reared in both socially and perceptually enriched environments and were found to out-perform animals raised in isolation in small barren cages. Forgays and Forgays (1952) found that rearing Ss in large open field apparati resulted in superior problem-solving ability than did rearing in smaller cages. They also found that animals reared with both social and perceptual enrichment were superior maze learners to Ss reared in socially enriched but perceptually impoverished environments. With cage size and social rearing conditions held constant as in the present study, there is little doubt that exposure to a perceptually complex environment for a 5 week period immediately postweaning led to superior discrimination learning ability in comparison to Ss deprived of the same degree of complexity.

Results of this research support those of Forgays and Forgays (1952). All animals were raised in

socially enriched, large open fields. Since experimenter manipulation of differential degrees of controllability was found to be insignificant, the obtained results must be considered to be solely a function of perceptual rearing conditions.

Response contingent or independent rearing conditions within each perceptual environment did not affect later discrimination learning. If RI rearing produced interference with subsequent learning ability both ERI and IRI groups would be expected to require more sessions and make more errors in attaining criterion than their RC counterparts. However, no such effect was observed nor was there any trend in this direction.

Results of the present research do not support a learned helplessness interpretation. This is not to suggest however, that early exposure to RC or RI events does not influence motivational and cognitive development as advocated by Seligman (1975), but simply that the test measure employed was more sensitive to perceptual than to contingent rearing conditions.

Results of Contingency analyses were few and inconsistent. The ERI Ss of run 1 attained acquisition with fewer errors than IRI animals. Similarly, ERC rats of run 2 made fewer errors to criterion than their IRC counterparts of the same run. Both findings support

a perceptual enrichment rather than a contingency interpretation. However, these results were not consistent across runs and must be considered somewhat ambiguous.

Results also indicated that ERI Ss of run 1 made fewer errors to acquisition criterion than EC rats of the same run. This result was unexpected. According to Seligman's (1975) theory of learned helplessness, C animals should perform at an intermediate level to RC and RI Ss, although not necessarily differ from either. It was not expected that they would make more errors than RI rats. When the run variable was collapsed no difference existed between ERI or EC Ss.

The observed performance discrepancies noted above, although equivocal, tend to support Hebb's prediction that exposure to early perceptual enrichment leads to a generalized increase in perceptual ability. There was no evidence to indicate that RC rearing facilitated acquisition or that RI rearing impeded it. If both perceptual and contingent rearing conditions influenced discrimination learning an Environment X Contingency interaction would be expected. In such an interaction the combination of enriched and response contingent exposure should augment subsequent performance while impoverished response independent rearing should impede it. However, this interaction

was not observed.

If the enrichment variable was sufficiently salient to overshadow any effect of contingent rearing, no differences should have been expected between enriched animals from different contingency levels. But within impoverished groups, RC rearing would be expected to facilitate performance in relation to RI Ss as response-reinforcer associations were made and strengthened in the absence of the degree of visual stimulation to which enriched rats were exposed. If RC rearing did induce a state of environmental mastery, helplessness theory would predict enhancement of learning about new contingencies in a different circumstance. Similarly, RI animals would learn of the independence between food delivery/light onset and their behavior which would interfere with subsequent learning. None of the predicted effects of learned helplessness theory were observed to transfer to the perceptual discrimination phase of the study.

A problem in assessing the effects of contingent and independent rearing in the present study was with the task and apparatus used. In order to employ a horizontal-vertical rectangle discrimination task in the discrimination box, a 9 day pretraining period was necessitated. Animals required adequate time for

adaptation and to learn to push open goal box doors for access to reinforcement. However, it is quite possible that the result of the pretraining period may have effectively reduced the effects of prior exposure to response contingent or independent reinforcers. Both Welker (1976) and Wheatley et al. (1977) presented evidence to indicate that experience with response independent appetitive events produces only a transient interference with learning.

These results differ with those of the typical helplessness experiment where animals subjected to inescapable aversive event such as shock, show a failure to escape from shock that doesn't dissipate in time (Seligman and Beagley, 1975; Seligman et al., 1975). Presumably animals acquire the expectation that shock onset and termination is independent of responding. When such an animal is placed in a test apparatus such as an operant chamber or shuttlebox it receives periodic shock which, if it fails to escape, confirms the expectation established during the preexposure phase.

In the present appetitive analogy RI Ss may very well have developed the same expectancy during the rearing period regarding their behavior and it's consequences as did their counterparts in an aversive paradigm; that responding was ineffective. When exposed

to the testing phase of the present experiment RI Ss may have entered that situation with a cognitive deficit in relation to RC Ss. However, all animals entered the pretraining period under the same level of water deprivation, and reinforcement was attained only after S entered the goal chamber. Thus, the pretraining phase provided all Ss with 'forced' exposure to a response-reinforcer contingency. If S did not enter the goal chamber directly there was no immediate consequence to it's behavior. Therefore, the degree of permanence of interference with learning following response independent appetitive events may have dissipated in the present study before discrimination training commenced.

Welker (1976) suggests that this transience is due to procedural differences in appetitive and aversive experiments; namely that the 'forced' exposure occurring during the testing phase of the appetitive design does not confirm the expectation that responding and reinforcement are independent. Thus, one must seriously consider the implications of the pretraining period of the present experiment and the possibility that it may have effectively eliminated any contingency differences established during the rearing period. If this in fact is the case, animals entering the

discrimination phase proper would already have learned that goal doors had to be pushed open for access to a sucrose concentration. At this point they would only have to differentiate between horizontal and vertical rectangles as cues and as prior research indicates enriched reared animals have a distinct advantage. This interpretation is supported by the results.

A second problem was inherent in the pretraining phase of the present research. Bainbridge (1973) found that following exposure to an insoluble discrimination problem, rats quickly gave up hypothesis testing on a soluble problem and reverted to highly consistent positional responding. If such position preferences adequately reflect a learning deficit due to prior experience with noncontingent and uncontrollable outcomes, the employment of an experimenter corrected procedure in the present study effectively eliminated position responding before acquisition training began. In future research of this nature a task must be employed which would eliminate the adaptation-pretraining phase and allow for immediate testing.

This implication has gained support from Seligman (1979) who suggested that a task that may be more responsive to both perceptual and contingent rearing

variables was escape/avoidance learning in a two-way shuttlebox on an FR 2 schedule. However, one must consider the possibility that such a task may be more amenable to contingent than to perceptual rearing conditions which would present a problematic test situation analagous to that of the present design.

Since Bainbridge (1973) did find highly stable positional responding in rats preexposed to an unsolvable discrimination problem and since such a problem is uncontrollable in the same sense that non-contingent food delivery/light onset was uncontrollable (Maier and Seligman, 1976), an ancillary measure of the acquisition phase was the number of persistent errors to criterion. If RI rearing resulted in subsequent interference with discrimination learning in the present study, as did preexposure to an unsolvable visual discrimination in the Bainbridge (1973) research, these Ss would be expected to exhibit more persistent errors to acquisition. However, no such deficit was observed.

Either RI rearing in the present research did not induce a generalized learning deficit analogous to exposure to an insoluble discrimination problem, or any influence it may have had was reduced by the use of an experimenter corrected procedure in the pretraining phase.

The only finding influenced by either perceptual or contingent rearing conditions was that ERC Ss made fewer persistent errors to criterion than IRC rats. This would suggest that differences were due to perceptual surroundings. The conclusion to be drawn from this finding is ambiguous as differences were of marginal significance. It does suggest that ERC Ss were able to break persistent positional responding more rapidly than IRC animals. It does not imply that intertrial position responses were extinguished faster but merely that the intratrial persistency of responding diminished faster.

More persistent errors to criterion were made by animals of run 1 than run 2. This was an unexpected finding and one that is difficult to explain as rearing and pretraining phases of both runs were standardized (except for the aperiodic noise of run 2). No differences were observed between runs in the total number of errors to acquisition.

Closer inspection of this data indicated that rats of the second run appeared to make fewer persistent errors from the first session of formal training. The number of persistent errors gradually declined so that by sessions 4-5 animals would make an error and when returned to the start box would respond to the

opposite position. However, Ss of run 1 made more persistent errors on session 1 which gradually declined until sessions 5-6 when their performance appeared similar to Ss of run 2.

It seems that differential persistent errors on the first training session made the greatest contribution to observed discrepancies between runs. This did not influence the number of sessions required or the total number of errors to acquisition criterion.

When an animal in the present research was persistent in responding, it was responding to position. Sutherland and Mackintosh (1971) present unequivocal evidence indicating that rats develop position preferences during the course of discrimination training. The employment of a simultaneous shape-orientation discrimination permitted S, when responding to position, to be effectively placed on a 50% partial reinforcement schedule, as position of the reinforcer was randomized according to Fellow's Sequence (1967). Spence (1936) found that reinforcement of a response was more effective than nonreinforcement in controlling behavior. This would allow a position habit to initially increase in strength. However, the experimenter-corrected procedure employed in the present study broke position responses faster than if a self-corrected procedure

had been used (Towart and Boe, 1965).

What appears to have occurred was that animals of the second run were able to learn faster that approaching a locked goal box door necessitated a position reversal when returned to the start box. The difference in the number of persistent errors between runs does not appear to be an artifact but the explanation must remain uncertain.

The final finding of significance during acquisition was that Ss trained with the horizontal rectangle as S^D learned the discrimination task faster and with fewer errors than those trained with the vertical rectangle. This was true regardless of rearing conditions. These results are in direct contrast to Tees (1968) who found that rats learned faster with a vertical rectangle as S^D. The modifications made to the goal door cues in the present study were expected to eliminate the horizontal-vertical discrepancy but instead reversed it. Since Lashley reported that rats attend only to the lower 1/3 of the stimulus goal door, it was likely that Ss in the Tees (1968) study took longer to respond to a horizontal rectangle because it was centered. Thus, they would be unable to perceive it as well as those trained with the vertical rectangle which extended

into the lower 1/3 of the door. In the present study both cues were located well within the lower third of the stimulus. Under such circumstances the horizontal rectangle appeared to facilitate rather than retard acquisition.

It is also possible that differences may have existed between the two studies based upon the strain of rat. Tees (1968) used hooded rats which have pigmented irises and hence better vision than the albinos used here. Nevertheless, the difference between horizontal and vertical cues was genuine but in no way did it interact with other variables to influence the results. Both enriched and impoverished animals trained with the horizontal rectangle as S^D learned the task faster and with fewer errors. It is of interest to note that although Ss trained with a vertical rectangle as the positive stimulus made more errors to acquisition they did not make more persistent errors than those trained with a horizontal rectangle. This indicates that once initial spatial responding was broken animals, irrespective of S^D, tend to reverse positions when an error was made.

Reversal Training

Results of the successive reversal phase of

the study found no differences between groups with regard to the number of reversals attained within 30 sessions. Neither perceptual nor contingent rearing conditions were influential. These data are inconsistent with Drech et al., (1962) who found that enriched rearing facilitated successive reversal learning with rats. Melzack (1962) reported similar results with dogs. Results support neither early experience nor learned helplessness theories.

The findings of the present research introduce the possibility that once intital acquisition criterion had been attained, there were no longer differences which carried over into the reversal phase. This runs contrary to Hebb's theory that the neurological changes produced by early enrichment would result in permanent facilitation of visual performance. Since so few studies employing an enrichment- impoverishment paradigm have used successive reversal methodology as a dependent measure, the facilitating effects of early enrichment on this task are equivocal.

One possible explanation for the lack of differences in the present study is that during acquisition, Ss learned to attend to the relevant stimulus dimension which remained relevant for the reversal. Once a particular strategy had developed it may have

transfered to the reversal phase with equivalent efficiency regardless of prior experience (Mackintosh, 1974).

A second possibility for the lack of differences was that the 30 session period was of insufficient duration. Mackintosh (1974) reported that when rats were trained on a simultaneous brightness discrimination task and then successively reversed, performance was poorer on the first reversal with animals making approximately three times as many errors as to initial criterion. Performance gradually improved with repeated reversals so that eventually only one or two errors were necessary before successful learning occurred. However, in the present research approximately only half the Ss were able to attain one reversal. Only 3 Ss performed more than one.

A more sound methodological plan would have been to run all Ss to acquisition of one reversal. This would have allowed a measure of the number of errors and sessions to reversal attainment. It would also be in contradiction of the assessment of Wong and Judd (1973) who suggested that successive reversal methodology was most likely to reveal group differences when a fixed period was used. If they were correct, 45-50 rather than 30 sessions may have been

required before differences were observed.

The only difference observed during reversal training was that IRI animals of run 1 were found to make fewer total errors throughout the 30 sessions than ERI Ss of the same run or their IRI peers of run 2. These differences are based on 6 animals/cell and are not consistent between replications. Thus, any interpretation must be guarded.

Results of the reversal phase lend very little information pertaining to either a perceptual or contingency explanation. This is primarily because Ss initially respond to the previously positive cue. Then position habits are established and broken before responding to the previously negative stimulus is able to predict location of the incentive concentration. It is apparent that 30 sessions was inadequate to measure group differences.

Summary

The present study demonstrated unambiguously the powerful influence of early environmental enrichment in comparison to impoverished rearing on discrimination learning. Even with cage size and social conditions held constant the enrichment effect was observed. Although the attempt to identify the dimension

of controllability as a contributing component in the early experience effect did not prove fruitful, this by no means suggests that it is without influence. It is reasonable to expect that the development of a sense of environmental mastery or helplessness at an early age will result in an enhancement or impairment of learning at a later period. However, it remains to be determined whether or not controllability or the lack of it, interacts with early perceptual rearing to affect motivation, response initiation, and the perception that responding is effective.

Although the present research was not expected to provide definitive results concerning the facilitation of learning due to earlier experience, it was hoped that it would bridge the gap presently existing between the areas of learned helplessness and early environmental enrichment, and serve a heuristic role for future research.

Clearly, a more appropriate task must be discovered and implemented in order to determine whether early exposure to response-outcome contingencies is an influential dimension in the early enrichment effect.

APPENDICES

APPENDIX A

DAILY RECORDINGS OF EXPERIMENTER OBSERVATION DURING RUN 1.

Daily Recordings of Experimenter Observation during Run 1

Day 1. All 6 groups were very active, exploring their respective environments - bar pressing and light pressing started within 5 min. but accidentally -food colouring was licked off almost immediately -very much activity.

Day 2. Very unusual behavior in IRC and IRI groups -IRC Ss congregate around 1 food dish and Ss are competing to place their nose in the feeding tube - other Ss climbing on the pile would accidentally press the bar and this is how feeding was occurring - yoked IRI Ss simply gathered at the yoked food hopper and waited for the hopper to be activated then they would fight to determine who would get the pellet - ERC Ss have many more objects to interact with so they are spread out more and thus, are able to feed individually - yoked E Ss don't compete for food in same manner as IRI Ss but they will run from 1 food dish to the next to see if any food is available - Ss in both ERC and IRC groups press for lights although IRC Ss seem more fascinated by them.

Day 3. IRC and IRI Ss still congregating around the food dish - these Ss even sleep on top of one another in the food dish - they do not appear to have learned how to get food even though they have pressed for it 1700 + times - ERC Ss have learned to bar press for food individually - since these Ss have so many objects to interact with it is possible for a single S to approach the bar and eat without being disturbed by others - these Ss eat at will. - Ss in ERI group are developing behavior patterns similar to IRI when they wait at the food dish for a pellet to drop and then fight for it.- EC group plays and interacts with environmental objects and are very active - IC Ss huddle in a group and are much more passive.

Day 4. ERC Ss demonstrate most operant behavior at night (i.e. after lights are out) whereas IRC Ss are active through both light and dark cycles - ERC Ss continue to feed at will - ERI are more relaxed in their feeding pattern and it is possible for a single S to approach food dish alone - IRC Ss still congregate around food dish and exhibit same behavior - IRI Ss actually have a supply of food accumulating and can approach and eat at will.

Day 5. IRC Ss are becoming less aggressive or competitive around food dish - now it is possible to see only 2 rather than 6 Ss at the dish together but they continue to be the most competitive group - IRI Ss are still feeding at their leisure

Day 6. IRC Ss are sometimes feeding individually and therefore learning to bar press for food - there is still some competition but not nearly as much as previously - IRI and ERI Ss often have a surplus of food in their dish and can eat at will - this is the first day that ERC pressed a greater no. of times than IRC

Day 7. ERC seems to be the most sluggish group during light hours - most of their bar and light presses occur when light is off - other 5 groups are very actively interacting with environments and other Ss - the no. of bar and light presses in IRC and ERC are very close - Ss in enriched groups spend a great deal of time playing in and sleeping in mazes - mazes are the most frequently used object in E environment - ERI group still has a surplus of food and thus Ss in this group are able to eat at their leisure and are there-

fore similar to control group - EC group is by far the most active and constantly interact with objects provided - food supply in ERI group appears to be building up - therefore rather than being in a response independent state they are more like an ad lib feeding group

Day 8. ERC has begun to use the other bar - now ERI has a surplus of food in the opposite food dish - IRC has pressed for much more food thanERC - but ERC is now making more use of light switches - Ss are starting to gnaw extensively but particularly around the feeding tube -IRC has now learned to bar press on an individual basis quite well but IRI still continues to fight for food when it is being delivered - this group literally climbs on top of one another squealing and pushing to get the next pellet - the problem is with ERI in that they aren't learning the food delivery is independent of their responding since all they have to do is approach the food dish and eat at will since there is a build-up of food from ERC.

Day 9. very little difference between no. of Rs for either ERC or IRC groups - however ERI does not have a surplus of food as they have for

the past 2 days but IRI now does - IRI has a very large surplus and actually has 1 Petri dish filled - as usual EC are very actively interacting and gnawing with objects in their environment while IC Ss are very lax and have a tendency to huddle in corners in groups of 3 or more.

Day 10. both ERI and IRI now have a surplus of food - all I groups seem to be running around much more than E groups (locomotor activity) -this is due to the fact that they have much more open space - while E Ss interact with enriching objects I Ss run and climb upon the mesh front wall - all RC group Ss have learned to press the bar for food - it is rare when more than one Ss is seen at the bar at any time - this is true of the IRC as well as ERC group

Day 11. ERC Ss are turning lights on much more than IRC - it is interesting to note that when ERC Ss press for lights they primarily use the "pull" switch while IRC Ss use the"omnidirectional" switch - Ss don't press several times then leave - lights are turned on in burst ranging from 5 - 20 responses at a time - when this occurs RI Ss will sometime sniff or look at the lights but one ERI S was observed to run

and hide inside tin can when light flashed on - there is still a very slight surplus of pellets in the food dishes of both RI groups - why they don't eat as much or as quickly as RC Ss is unknown - C group Ss are fed at 11:00 a.m. each day and usually by 8:30 p.m. they have eaten that days food

Day 12. still a slight food surplus in ERI and IRI groups - ERC are now turning lights at least 3 times as often as IRC Ss

Day 13. EC group are extremely active during light hours in relation to all other groups and ERC is becoming more active during light hours as time progresses - the 3 I groups are becoming less active in relation to E groups.

Day 14. no. of Rs for light in IRC is actually decreasing while ERC have been pressing at a much greater rate - ERC still show a preference for the pull switch while IRC use the omnidirectional switch more - a slight food surplus still exists in yoked cages - the difference between EC andIC in activity levels is acute with EC being by far most active - both groups have learned that when I approach their feeding dishes around 11:00 they will be fed - Ss

congregate as a group at their food dishes when I approach - Ss in all groups appear to have habituated to E presence and will continue to respond for lights or food or comply play while being observed - noticed yesterday that ERI had completely chewed off the dowel at the end of the pull switch - by today the wood dowel in all but IRC group were completely gnawed away -they were replaced - immediately after replacing dowel in ERI cage Ss began pulling and biting at it this is interesting because they had been observed exhibiting this behavior when ERC Ss were turning the lights on therefore may have superstitious or autoshaping behavior developing in ERI group - after replacing dowel ERC Ss immediately began pulling for lights -however, it is unlikely that superstitious or autoshaping behavior is occurring in ERI group - observed that as ERC Ss were pulling switch for lights to flash both ERI and EC Ss were pulling on the same pull switch at approx. an equal frequency - ERC Ss appear to be pulling at switch not just for light but because it can be "manipulated" and to chew at it - while ERI was experiencing same no. of light flashes as

ERC, EC were never exposed to onset of lights even though they pulled and gnawed at dowel an equivalent period of time.

Day 15. ERC appears to be making a phenomenal no. of light presses but most of these result from Ss chewing on the wooden dowel - whether or not they find turning lights on reinforcing is uncertain - IRI no longer has a food surplus but ERI still does.

Day 16. wooden dowel was replaced on all but IRC cage yesterday - by today all were chewed completely off except IRC - will replace tomorrow with metal spacers.

Day 17. IRI has no food available in Petri dishes and are beginning to gather at food dishes waiting for next pellet to arrive and when it does there is pushing, squealing, etc. - some Ss run from one dish to the next in anticipation of food -ERI still has a surplus, although it is slight they don't seem to eat as much as ERC or EC groups - both IRC and ERC continue to gradually increase the amount consumed - now have metal spacers on pull switch for lights in all cages but IRC - Ss are not turning lights on as frequently - high no. was likely due to chewing rather than

reinforcing properties of controlling light

Day 18. what is becoming quite apparent is the differences in activity levels between E and I groups - I groups are beginning to lay as a group in a corner while E groups continually interact with objects in their cages - I groups used to be as active as E groups and constantly ran around the cage and climbing the front mesh wall - however, they still appear to be active at night as this is when most pressing for food and light occurs.

Day 19. both ERI and IRI have a slight food build up again -when this occurs Ss are able to feed ad lib - when no food is available Ss are observed to hang around or run back and forth from feeding tube to feeding tube just waiting for the next pellet to drop - both C groups also have a surplus of food greater than that in RI groups -changed metal spacers on shafts to lucite rod

Day 20. still a surplus of food in RI and C cages -one thing that I did not want to see happen in RC cages was to have one S bar pressing for food and feeding another S - what was observed today was very interesting - one ERC S approached a bar and began bar pressing - very shortly

another S joined it at the bar - the first S continued bar pressing and both Ss fed together without any sign of competition for food - but when the first S had finished eating and left the bar the S that had been "freeloading" immediately approached the bar and continued feeding (altruism?)

Day 21. a large surplus in IRI cage but none in ERI -IRC Ss have gradually been decreasing the frequency of responding on the microswitch bar and been building up on the standard bar - ERC Ss still have a preference for the microswitch - for some unexplained reason the frequency of Rs for light decreased dramatically in the last 24 hr.

Day 22. light responses still greatly reduced - but Ss are making more use of metal food bars - slight surplus of food in ERI cage but what was observed was that one S, rather than eating pellets which were readily available was eating feces.

Day 23. Ss again making many light responses - it appears that amount of food being consumed is beginning to stabilize between 33-34 hundred pellets/cage.

Day 24. surplus of food has vanished in both ERI and IRI cages although a buildup is beginning in both C

cages - in RC cages feeding is a very casual process - it is very rare when more than one S is observed at the food dish at any time.

Day 25. no change

Day 26. Ss are eating or gnawing away wood dowel at end of pull switch for lights that it has to be changed daily - there is some competition for food in both RI cages as the surplus no longer exists - this is characterized by squealing, pushing, etc.

Day 27. surplus again exists in ERI cage but not in IRI -ERC Ss appear to be extinguishing responding to metal bar while IRC Ss are stabilizing responding at ½ -1/3.

Day 28. no surplus again in RI cages - what is most unusual is the variation in no. of light responses within RC groups on a daily basis -may range from several thousand to several hundred from day to day - both RC groups have a preference for a particular switch albeit a different one - should have noted that on day 26 wood dowel was changed to a piece of rectangular plexiglass to prevent amt. of chewing - this doesn't seem to have any great effect on no. of light responses in either RC groups.

Day 29. activity level of I Ss in relation to E remain quite low - I Ss seem to congregate as a group in a corner and sleep - E Ss wander around the apparatus individually, exploring and interacting with objects in it.

Day 30. ERC Ss made no responses on the metal bar while IRC continue to make 1/3 Rs on this bar - no difference in force between the 2 cages appears to be required in order to activate the 2 bars -number of light Rs appears to be declining since introduction of plexiglass pull switch (this will have to be introduced on the same day for the replication group.

Day 31. both groups(RC) made a phenomenal no. of food responses - there is only a slight surplus in ERI and IRI cages and in C cages the previous days food is gone - the E apparati are becoming badly gnawed in some areas such as the ramps.

Day 32. Ss begin using metal bar in ERC environment again because microswitch bars' dispenser was plugged therefore they have learned the task but prefer the other bar - why? - facility, position preference? - both C groups become very excited when I change water bottles and congregate in area where water bottle will be replaced

- reason unknown - perhaps because they don't receive as much attention from E as other groups - other groups usually continue to carry on with whatever they were doing

Day 33. both RI groups competing for food even though RC groups are pressing for more pellets.

Day 34. IRC 2 food hopper plugged therefore a greater demand on IRC 1 bar for food - both C groups continue to be very excited when I approach their cages for observation or to change water bottles.

Day 35. removed all Ss beginning at 11:00 a.m. using E double blind procedure - all Ss in I groups were very passive and very easy to remove from cages - very few tried to run or escape when being removed -E groups on the other hand immediately run for the security of the maze - maze had to be unbolted from floor and tipped up in order to remove Ss which were very resistant.

APPENDIX B

MEAN NO. OF RESPONSES FOR FOOD DELIVERY DURING REARING FOR ERC AND IRC GROUPS OVER SEVEN (5 d.) BLOCKS FOR RUNS 1 AND 2.

Mean No of Responses for Food Delivery during Rearing for ERC and IRC Groups over Seven (5 d.) Blocks for Runs 1 and 2

BLOCK		ERC	IRC
1	Run 1	1517.0	1585.2
	Run 2	1508.6	1537.0
2	Run 1	2448.4	2637.8
	Run 2	2234.6	2146.6
3	Run 1	3183.4	3142.6
	Run 2	2989.4	2860.4
4	Run 1	3496.0	3457.8
	Run 2	3362.2	3482.6
5	Run 1	3304.2	3229.0
	Run 2	3720.8	3453.8
6	Run 1	3570.2	3315.2
	Run 2	3690.4	3793.2
7	Run 1	3968.8	3620.8
	Run 2	4010.4	4107.6

APPENDIX C

MEAN NO. OF RESPONSES FOR LIGHT ONSET DURING REARING FOR ERC AND IRC GROUPS OVER SEVEN (5 d.) BLOCKS FOR RUNS 1 AND 2

Mean No. of Responses for Light Onset during Rearing for ERC and IRC Groups over Seven (5 d.) Blocks for Runs 1 and 2.

BLOCKS		ERC	IRC
1	Run 1	71.2	255.0
	Run 2	337.0	310.8
2	Run 1	232.4	176.4
	Run 2	399.4	1367.2
3	Run 1	1613.2	477.0
	Run 2	714.6	1264.2
4	Run 1	2847.2	2587.6
	Run 2	843.8	953.0
5	Run 1	1081.8	1148.0
	Run 2	277.2	213.2
6	Run 1	1528.8	588.0
	Run 2	173.8	713.0
7	Run 1	143.6	221.2
	Run 2	1065.8	347.8

APPENDIX D

RAW BOLI SCORES FOR INDIVIDUAL ANIMALS OVER TEST SESSIONS FOR RUNS 1 AND 2

Raw Boli Scores for Individual Animals over Test Sessions for Runs 1 and 2.

	ERC				IRC		
	ANIMAL NO.	SESSION			ANIMAL NO.	SESSION		
		1	2	3		1	2	3
Run 1	2	0	0	0	4	0	0	0
	11	0	0	0	8	0	0	0
	17	0	0	0	15	0	0	0
	24	0	0	0	23	0	0	0
	29	0	0	0	30	0	0	0
	32	0	0	0	35	0	0	0
Run 2	42	2	0	4	39	0	0	0
	44	0	0	0	45	4	3	0
	49	1	0	0	54	6	2	1
	57	4	0	0	59	0	0	0
	66	4	5	0	65	0	0	0
	67	3	0	0	70	4	1	0
		ERI				IRI		
Run 1	3	0	0	0	5	8	3	0
	9	1	0	0	12	0	0	0
	13	10	0	6	16	3	4	0
	21	5	0	0	20	0	0	0
	27	0	0	0	26	0	0	0
	36	0	0	0	33	0	0	0
Run 2	37	0	6	0	41	1	0	0
	46	1	0	0	47	0	0	0
	53	0	0	0	50	3	1	0
	56	3	0	0	60	3	0	0
	64	3	0	0	63	0	0	0
	69	2	0	0	71	2	2	2

Raw Boli Scores for Individual Animals over Test Sessions for Runs 1 and 2 (con't).

	ANIMAL NO.	EC SESSIONS 1	2	3	ANIMAL NO.	IC SESSIONS 1	2	3
Run 1	6	2	0	0	1	3	0	0
	10	0	0	0	7	0	0	0
	18	5	3	0	14	0	0	0
	22	0	0	0	19	0	1	5
	28	0	0	0	25	0	0	0
	34	3	4	0	31	0	0	0
Run 2	38	4	2	0	40	0	0	0
	43	0	0	0	48	4	2	5
	52	4	0	0	51	3	3	4
	55	0	0	0	58	0	2	0
	62	1	0	0	61	0	0	0
	68	3	0	0	72	0	0	0

APPENDIX E

TOTAL NUMBER OF SESSIONS (MAX=22),ERRORS, PERSISTENT ERRORS TO ACQUISITION CRITERION, TOTAL NUMBER OF ERRORS AND REVERSALS ATTAINED DURING REVERSAL TRAINING BY INDIVIDUAL ANIMALS

Total Number of Sessions (max=22), Errors, Persistent Errors to Acquisition Criterion, Total Number of Errors and Reversals Attained during Reversal Training by Individual Animals

ANIMAL NO.	SESSIONS	ERRORS	PERSISTENT ERRORS	REVERSAL ERRORS	NO. OF REVERSALS
			ERC		
2	11	64	21	242	0
11	11	90	33	210	1
17	10	63	12	192	0
24	5	29	12	197	1
29	9	50	20	200	1
32	15	89	25	262	0
42	16	106	12	203	0
44	8	59	23	220	1
49	8	37	10	231	0
57	10	48	1	215	1
66	12	62	5	256	1
67	12	69	11	242	0
			ERI		
3	6	34	14	246	1
9	9	61	23	186	1
13	11	74	19	227	0
21	6	49	25	274	1
27	7	38	13	207	0
36	13	68	19	233	0
37	15	75	11	197	0
46	11	77	27	213	0
53	12	56	12	221	0
56	12	74	19	204	1
64	14	89	13	233	0
69	7	48	15	215	1

Total Number of Sessions (max=22), Errors, Persistent Errors to Acquisition Criterion, Total Number of Errors and Reversals Attained During Reversal Training by Individual Animals (con't)

ANIMAL NO.	SESSIONS	ERRORS	PERSISTENT ERRORS	REVERSAL ERRORS	NO. OF REVERSALS
			EC		
6	8	60	22	138	5
10	18	154	69	259	0
18	12	84	28	199	0
22	12	74	30	229	0
28	6	41	19	222	1
34	17	111	18	216	0
38	17	86	13	211	0
43	10	40	5	215	1
52	11	73	18	208	0
55	15	84	14	233	1
62	13	80	17	226	0
68	6	36	11	249	1
			IRC		
4	9	61	22	186	1
8	13	101	33	232	0
15	10	95	40	213	1
23	8	78	40	215	1
30	9	58	21	216	1
35	14	82	27	228	0
39	21	136	23	213	0
45	9	40	1	187	1
54	10	58	12	204	0
59	19	122	20	213	0
65	12	85	20	210	0
70	11	88	39	188	0

Total Number of Sessions (max=22), Errors, Persistent Errors to Acquisition Criterion, Total Number of Errors and Reversals Attained During Reversal Training by Individual Animals (con't)

IRI

ANIMAL NO.	SESSIONS	ERRORS	PERSISTENT ERRORS	REVERSAL ERRORS	NO. OF REVERSALS
5	13	96	30	203	0
12	15	84	14	109	6
16	22	153	24	213	0
20	8	47	13	149	5
26	8	40	9	207	1
33	15	101	31	255	0
41	21	105	9	205	0
47	10	54	13	221	1
50	9	53	18	225	1
60	8	55	16	225	1
63	12	76	19	235	1
71	14	59	15	249	0

IC

1	10	74	23	237	0
7	21	135	34	232	0
14	10	75	22	223	0
19	9	51	12	218	1
25	7	32	9	219	1
31	15	93	11	193	1
40	17	101	31	234	0
48	12	54	8	194	1
51	8	43	9	208	1
58	17	95	25	189	0
61	17	95	15	241	0
72	12	82	16	211	0

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